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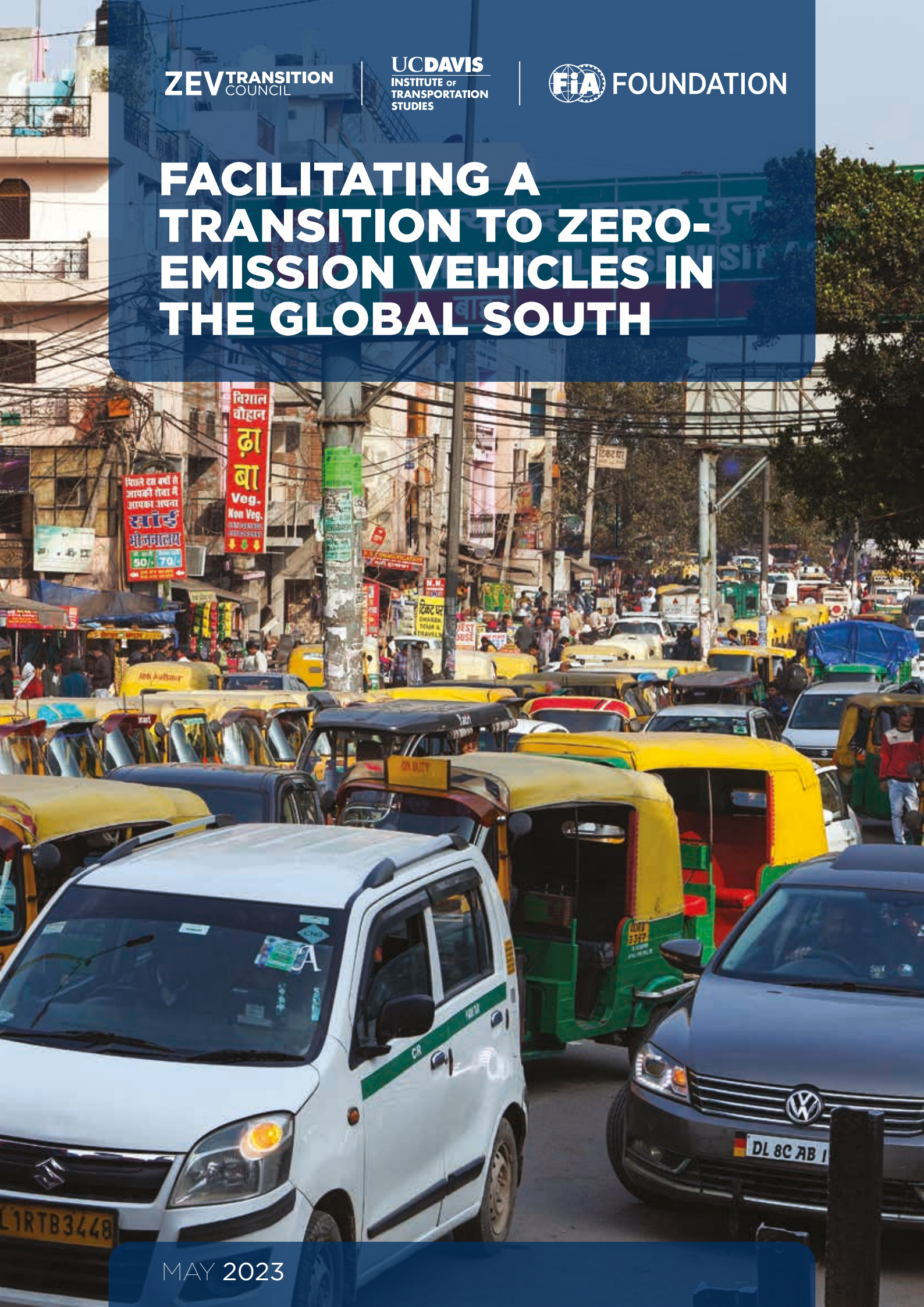
FACILITATING A TRANSITION TO ZERO-EMISSION VEHICLES IN THE GLOBAL SOUTH



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LIST OF ACRONYMS

BEV	Battery Electric Vehicle
CEPA	Comprehensive and Enhanced Partnership Agreement
CFE	Comisión Federal de Electricidad
CPPWG	Country Projects and Partnerships Working Group of the ZEVTC IAT
DRC	Democratic Republic of the Congo
EEA	European Economic Area
EFTA	European Free Trade Association
ESG	Environmental, Social and Governance
EU	European Union
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
GFEI	Global Fuel Economy Initiative
GHG	Greenhouse Gas
HIC	High Income Country
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
LMIC	Low- and Middle-Income Country
MDB	Multilateral Development Bank
NDC	Nationally Determined Contribution
OEM	Original Equipment Manufacturer
PHEV	Plug-in Hybrid Electric Vehicle
SDG	Sustainable Development Goals
SIDS	Small Island Developing State
SUV	Sports Utility Vehicle
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
US	United States
ZEV	Zero-Emission Vehicle
ZEVTC	ZEV Transition Council
ZEVTC IAT	ZEV Transition Council's International Assistance Taskforce

EXECUTIVE SUMMARY

This report reviews the status of energy and decarbonisation policies for road transport, paying specific attention to measures related to zero-emission vehicles (ZEVs). ZEVs are vehicles capable of travelling without tailpipe emissions of local pollutants and greenhouse gases: mainly battery electric (BEV), plug-in hybrids (PHEVs), and fuel cell electric vehicles (FCEVs). It builds on reviews of ZEV policy frameworks, additional desk research and inputs from a survey answered by around over 100 policymakers and stakeholders working in transport, energy and environmental policies in the Global South.[1]

This work also benefited from inputs derived from the Global Fuel Economy Initiative (GFEI) experience, developed during more than a decade of work with countries in the Global South.

The geographical coverage of this analysis includes all members of the G20, the 20 most populated countries, signatories of the Acceleration to Zero Coalition and a selection of other countries that have been supported by the GFEI over the years, including markets in Africa, Latin America and Asia, encompassing a number of Small Island Developing States (SIDS).

Drawing on an analysis of different country clusters, this assessment identifies topics for which increased availability of funding from multilateral development banks for a ZEV transition can be strengthened. The analysis also suggests how to leverage the potential of existing platforms of international cooperation to facilitate key policy developments in Low- and Middle-Income Countries (LMICs), paying specific attention to cases with deep policy gaps to build capacity to receive and effectively use these disbursements.

STATUS OF THE ZEV TRANSITION

The ZEV transition has shown and keeps showing a positive momentum worldwide, in particular due to increased Electric Vehicle (EV) uptake. Although much of the focus received by EVs in the public debate is on cars, this is not the market segment where EVs reached the largest market shares. In 2022, two wheelers and buses saw a higher EV penetration, globally, than electric cars and light commercial vehicles.

Despite positive signals, the distribution of ZEVs across the world remains uneven. For two wheelers, the size of the EV market is largely led by with the 50 million electric motorcycles and low-speed "bikes" sold in China. The global regions with the largest market shares of e-buses are China (roughly a quarter of all buses) and Europe (close to 12%). Chile and Colombia are home to the largest fleets of e-buses in the Global South after China. Significant differences in terms of EV adoption across global regions are also noticeable in the light vehicle segment, with only a fraction of electric car and light commercial vehicle sales occurring beyond Canada, China, Europe, the Republic of Korea[2], Japan, and the United States (US).

The low EV adoption in LMICs, observed in all segments (even though these markets contribute significantly to Internal Combustion Engine Vehicle (ICEV) sales, due to a growing vehicle ownership) is indicative of the challenge of decarbonising road transport in these geographies. Reasons for this are linked with the nature of these markets, often characterised by less reliable electricity supply, lower vehicle prices, comparatively low household incomes, low availability of asset finance at affordable rates and, especially in countries that do not have assets in the automotive value chain, significant flows of used vehicle imports.

STATUS OF CURRENT POLICY DEVELOPMENTS

Policy actions related with fuel economy improvements, the ZEV transition, a shift towards low-carbon electricity and the enhanced sustainability of the battery supply chains are also heterogeneous globally.

- Vehicle manufacturing countries have been more proactive than non-manufacturers in taking legislative action on all these topics.
- Countries that are net importers of oil and petroleum products are more likely to have policies on energy efficiency (fuel economy) and the ZEV transition (ZEV deployment and related infrastructure, in particular charging for EVs) than oil exporters or countries that are self-sufficient regarding their oil and petroleum product supply.
- High income countries (HICs) are generally ahead of LMICs in the development of environmental legislation, across the board.

FUEL ECONOMY

Policy developments on fuel economy took place to a greater extent on legacy technologies (ICE vehicles), especially amongst countries with vehicle manufacturing capacity, and also (thanks to opportunities to increase exports by limiting domestic demand) in high-income net oil/product exporting countries.

ZEV AND RELATED INFRASTRUCTURE

ZEV policies can offer opportunities to leapfrog[3] some of the policy development stages typically characterising fuel economy policy. The best leapfrogging opportunities are found in:

1. SIDS;
2. Countries with automotive manufacturing facilities and that have already spotted a development opportunity from a shift to EVs; and
3. Countries that, as net importers of oil and petroleum products, see ZEVs as an opportunity to reduce their exposure to oil price volatility and other energy security risks, especially if their electricity generation is largely based on renewable energy.

Countries showing the largest distance from leapfrogging opportunities are net oil/petroleum product exporters or self-sufficient producers. Overcoming this specific challenge is especially important and likely to require dedicated activities.

DECARBONISATION OF THE ELECTRICITY GRID

Given their greater energy efficiency, ZEVs are less carbon intensive than ICEVs even before the electricity grid is fully decarbonised. However, decarbonising the electricity grid is instrumental in order to maximise the environmental, economic and health-related benefits of electromobility.

Improvements are possible - and more urgent - in LMIC markets which are still distant from having attained lower emission levels and significant growth expected in terms of scale, due to increased motorisation. Across all countries, based on emission intensity of the electricity grid, classification in terms of policy ambition, and market size, the following countries are amongst the main priorities: Iran, Egypt, Malaysia, Thailand (mainly for policy ambition and timelines), South Africa, and Uzbekistan and the United Arab Emirates.

BATTERY SUSTAINABILITY

Battery manufacturing, supply chain sustainability and end-of-life management is clearly the area with a major gap in policymaking, especially in medium to minor markets, but also - on the topic of sustainable sourcing of minerals - in most major markets but the European Union (EU). Reasons for this include both the novelty and the complexity of this subject for transport policymaking, since the increasing competitiveness of ZEVs (in particular EVs) is a fairly recent phenomenon.

Policies and regulations to ensure that the framework in which ZEV policies are developed do not replicate unsustainable business models are decisive, especially in countries where mineral extraction and battery manufacturing has started or is set to start soon. Waste management (namely improve material recovery and recycling) could cover a considerable part of upcoming material demand, which would be urgently needed in LMICs, given their reliance on second-hand vehicles.

Policy action on batteries, from end-of-life management to supply chain sustainability, is clearly lagging in LMICs without a car manufacturing industry. Battery end-of-life management policies are more advanced in oil importing countries (due to greater interest in energy diversification) than in oil exporting ones, especially for LMICs.

The case with the deepest policy lag and the largest relevance in terms of size of the market affected is in countries with the presence of an auto manufacturing capacity and self-sufficiency or net oil/petroleum product exports. This confirms the criticalities already observed in the case of ZEV and charging infrastructure policies.

OPPORTUNITIES FOR PROGRESS

Despite remaining challenges, LMICs have the possibility to seize important opportunities from a global EV transition that is bound to continue over the next decades. Arguments that support this idea include:

- Capacity to address the twin objectives of emission reduction and development, by creating new value chains in the economy through the e-mobility ecosystem.
- Significant shares of vehicles with high rates of daily usage, including boda bodas, taxis, buses and light commercial vehicles, as they benefit the most from lower operational costs, and provide the most important mobility services in the form of public transit and first / last-mile connectivity.
- Low power demand for electric two-wheelers, making them better suited for charging in locations with a grid infrastructure that is still being developed.

- Limited exposure to the asset stranding risks than those faced by HICs with a strong automotive sector (even if asset stranding challenges also exist in LMICs, especially if they have a vehicle manufacturing industry and are fossil energy exporters).
- Opportunities – also relevant for the transition of vehicle maintenance, servicing shops and eventually larger assembly facilities – from the repowering/repurposing of ICEVs into BEVs, through retrofits.
- Additional opportunities, for countries with a high level of endowment in battery materials, to retain greater portions of the EV and battery value chain.

As HICs transition their economies towards greater alignment with sustainability (including through reductions in the emission intensity of the products that they use and trade), countries that have achieved a successful transition towards low-carbon electricity (and energy systems more broadly) are amongst those with the greatest chances to intercept opportunities to have access to export markets for their products. Making sure that all countries can effectively migrate towards this type of condition (as well as other sustainability requirements) will need to be taken as a priority.

NEED FOR ENHANCED POLICY ACTION

Policy action that helps kicking-off and sustaining the ZEV transition is a prerequisite to enable and ensure the economic viability of ZEV-related investments. The policy tools needed to stimulate the transition have already been identified and remain relevant to accelerate change.

- **SET CLEAR PRIORITY AREAS FOR POLICIES THAT WILL ENABLE THE ZEV TRANSITION**

  Defining key policy tools and priority areas for policy action will be essential to enable and ensure the economic viability of ZEV-related investments. These include technical standards and regulations, information and communication, efficient levels of energy taxes and carbon prices, procurement, economic incentives, regulatory limits, green investment frameworks, trade policies, industrial development support, and workforce support. Rules are likewise needed to facilitate an effective functioning of the electricity market. The largest investments and funding requirements needed for ZEV transition are crucial for cases with the biggest risk of a growing divide with a transition towards the biggest risk of a growing divide with a transition towards development aligned with the Sustainable Development Goals (SDGs), in particular countries that are net exporters of oil/petroleum products

- **FRAME THE ZEV POLICY ACTION IN A BROADER AGENDA FOR DEVELOPMENT AND SUSTAINABILITY**

  Taking action to reduce remaining policy gaps needs to be framed in the context of a broader effort by HICs to support LMICs (especially countries with significant exports of products and services, or seeking that) to transition towards sustainability in a holistic way. A key reason for this is that LMICs risk facing trade barriers if HICs shift towards a development model that aims to generate value in a sustainable way (e.g. through the circular economy, ecosystem services or decarbonised and dematerialised, outcome-based services). A lack of support for LMICs to quickly develop policies enabling them to transition towards low-carbon technologies - including but not limited to ZEVs - risks to increase geopolitical tensions due to reduced access to major markets, as the HIC growth strategies are shifting towards a better alignment with the SDGs.

- **REDUCE THE COST OF CAPITAL FOR SDG- AND ZEV-ALIGNED INVESTMENTS IN LMICS**

  Due to challenges for LMICs to get access to affordable capital and the possibility for Multilateral Development Banks (MDBs) to borrow (and therefore also lend) and at very favourable terms, an increase in the lending capacity of MDBs for projects characterised with a better alignment with the SDGs could be instrumental to facilitate access to affordable capital for all countries, freeing up opportunities to accelerate an inclusive transition. The development of an internationally agreed, science-based international classification system, establishing a list of environmentally and socially sustainable economic activities (a taxonomy) is a likely prerequisite to enable an effective increase of SDG-aligned MDB lending. As the work pioneered by the European Union demonstrates, a taxonomy of sustainable activities would most likely include ZEVs, low-carbon electricity and charging infrastructure.

- **LEVERAGE EXISTING PLATFORMS TO FACILITATE KEY POLICY DEVELOPMENTS IN LMICS**

  Leveraging existing international platforms to facilitate exchanges between governments and other stakeholders working in LMICs can be a useful tool to share best practices and accelerate alignment with the SDGs and the ZEV transition. These platforms have already developed extensive networks and gathered subject-matter experts, making them effective in fostering sectoral and cross-sectoral dialogues and integrating dedicated activities to bridge capacity gaps for LMIC policymakers.

- **ELABORATE A COMPELLING VALUE PROPOSITION TO TRANSITION TOWARDS ZEV IN LMICS AND PROMOTE THE ENHANCEMENT OF CHARGING INFRASTRUCTURE AND LOW-CARBON ELECTRICITY POLICIES**

  Proactive measures are needed to accelerate ZEV, charging infrastructure and low-carbon electricity policies. Opportunities for this transition include leveraging like-to-like situations, accelerating the electrification of highly-utilised vehicles, and transitioning to two-wheelers. Complementary measures may include right-sizing vehicles and batteries, and seeking consensus on economic diversification strategies for oil/petroleum exporting countries.

- **ENSURE THAT ALL WORLD REGIONS DEVELOP BATTERY RECYCLING CAPABILITIES, AND ALL COUNTRIES ESTABLISH REGULATORY STANDARDS FOR THE END-OF-LIFE MANAGEMENT OF BATTERY MATERIALS AND THE SUSTAINABILITY OF THEIR SUPPLY CHAINS**

  The sustainability of batteries and their supply chains have been identified as a critical bottleneck for the EV transition. International cooperation and initiatives to align battery production with environmental sustainability must be reinforced to ensure that all world regions develop battery reuse and recycling capacities and establish procedures for the end-of-life treatment of battery materials and governance standards. Adherence to the United Nations' Universal Declaration of Human Rights, and making proactive efforts to develop an inclusive governance, will also be key for a successful, ethical transition to ZEVs.

- **SUPPORT IMPROVEMENTS IN SECOND-HAND VEHICLE TRADE**

  Improvements in the second-hand vehicle trade can be enabled by providing better access to data and by taking a macro-regional approach to support greater harmonisation in policies (e.g. across all Africa). This will facilitate the development of a stronger framework that would tighten up technical inspections and trade flows. It will be important to balance the advantages and the disadvantages that a reduction in second-hand vehicle exports from HICs could have on affordability of enhanced access to mobility and environmental impact, since it could trigger demand for ICEVs from other producing countries which have potentially less strict emissions regulations.

- **ASSIST LMICS TO ADOPT ROAD USER CHARGES, AMONG OTHER MEASURES, AS A SOLUTION TO BRIDGE BUDGETARY CHALLENGES**

  Road user charges are likely to be important to make up for lost fuel-duty revenues accompanying the ZEV transition and to adequately price vehicle use. The shift to road user charges is complex. It requires anticipation and finding a balance between stimulating innovation while addressing revenue shortfalls and social equity impacts. A digital transition could significantly facilitate the application of road user charges, and enhancing support for this development in LMICs is important for an economically sustainable ZEV transition.

PREMISE

Climate change, caused by human-induced changes in greenhouse gas (GHG) concentration in the atmosphere, is a threat to most life and ecosystems on Earth. Continued emissions will lead to increasing global warming and spur the intensification of multiple and concurrent hazards (**IPCC,2023**).

Limiting global warming entails neutralising CO_2 emissions. The rate and the extent of these reductions will largely determine whether warming can be limited to 1.5°C or 2°C. Yet, countries commitments, as stated in their Nationally Determined Contributions (NDCs), hinder scenarios where warming will stay below 2°C (**IPCC,2023**). Moreover, there are gaps between projected emissions from implemented policies and those from NDCs, and finance flows fall short on the levels needed to meet climate goals across all sectors and regions.

Deep, rapid and sustained mitigation and adaptation actions by 2030 will lead to a discernible slowdown in global warming within around two decades, reduce projected losses and damages for humans and ecosystems and deliver many co-benefits, especially for air quality and health. System transitions across all sectors are necessary to achieve these emission reductions and secure a liveable and sustainable future for all (**IPCC,2023**).

RATIONALE FOR THE ZEV TRANSITION

Some solutions are offered to alleviate prospects for increased emissions of the transport sector. In road transport, which accounts for over 75% of total transport CO_2 emissions and is almost entirely reliant on oil and petroleum products (**IEA, 2022a**), EVs[4] powered by low-carbon electricity present the largest decarbonisation potential (**IPCC, 2022**), on a life-cycle basis. This, along with considerations grounded on better cost effectiveness and less limiting factors, indicate that the electrification of road transport is vital to meet the goals of the Paris Agreement on climate change (**ZEVTC, n.d.**).

ZEVs – in particular EVs – are therefore a good fit to comply with the pledges to achieve net-zero GHG emissions by 2050,[5] made by a wide range of countries (**UNFCCC, n.d.**), although in most cases climate change mitigation and adaptation policies, as set out in NDCs, are conditional on foreign assistance. EVs are also aligned with improved health impacts of road transport, thanks to the abatement of emissions of local air pollutants, especially in urban areas (**World Bank, 2022**), despite the need to address non-exhaust emissions of particulate matter.[6]

OPPORTUNITIES FOR AN INCLUSIVE ZEV TRANSITION IN THE GLOBAL SOUTH

The possibility to foster industrial developments (for production and assembly of vehicles), adds to climate and health-related considerations a major reason to consider the ZEV transition in LMICs as an opportunity.[7] Key motivations lie in a lower manufacturing complexity for EVs with respect to ICEVs and the commoditisation of many EV components, coming with the possibility to bridge the barriers posed by large investments required for ICEV manufacturing (**World Bank, 2022**).

The prospect of promoting more inclusive and affordable forms of mobility, such as two and three-wheelers, increases the potential for aligning the ZEV transition with the needs of LMICs. In addition to this (as shown by the manufacture of novel transport vehicles in China, including electric kick scooters), the absence of combustion engines can offer a wide variety of opportunities to deploy new technologies and products.[8] While current manufacture of ZEVs remains highly concentrated, Box 1 provides examples of LMICs that have already started to develop a domestic production of ZEVs or have a roadmap to do so.

These development opportunities could make the ZEV transition a catalyst to transform investments, even beyond the transport sector, especially when countries set clear direction and purpose with policies and regulations. The reason is that these signals enable dynamics in which other actors (i.e. private companies) could contribute to tackling complex challenges and achieving common goals. This can also bring increases in total investment, innovation and ultimately productivity (**Mazzucato, 2023**).

E-mobility can indeed be instrumental for investments in a low-carbon energy system, such as the deployment of new renewable electricity generation capacity or structuring developments of electricity grids. A clear example is the case of electric bus depots. As these are major electricity end-use facilities, their development, driven by cost effective competitiveness with diesel buses (in many cases[9]), can reduce investment risks for grid reinforcements and new developments.

Box 1. Examples of LMICs becoming ZEV producers

Several LMICs are capitalising on the ZEV transition to develop their local ZEV manufacturing and retrofitting capacities. Over the last years, some LMICs have been using international support for financial and technical assistance to stimulate their domestic production industry and partner with international manufacturers (**ICCT, 2022a**).

Thailand has set the target of 30% of two and three-wheelers, light-duty vehicles and urban buses domestically produced to be EVs (**ICCT, 2022a**). Indonesia has committed to 30% of annual vehicle production to be ZEV by 2035,[11] and of almost 8 million electric two-wheelers by 2025 (**ICCT, 2021a**).

In Africa, Kenya launched the first African designed and locally assembled e-bus (ROAM, formerly Opibus) last year, while Egypt partnered with a Chinese automaker to produce a total of 2,000 e-buses with at least 45% local components (**IEA, 2022b**). The continent is also seeing an expansion of two and three-wheeler e-mobility businesses (**ICCT, 2022a; World Bank, 2022**). Uganda has witnessed the emergence of start-ups Zembo and Bodawerk (**The Independent, 2022**; **Bodawerk, n.d.**), specialising in e-boda bodas and e-tuk tuks. In Rwanda, Ampersand has been assembling electric motorcycles since 2019 (**Government of Rwanda, 2019**).

The surge of locally produced ZEVs is also being experienced in other parts of the world. Bosnia and Herzegovina announced the creation of its first domestically designed and built electric light delivery vehicle in January 2023 (**N1, 2023**). 'Gou Argentina' is the first ride-hailing service that will offer from March 2023 the possibility to travel in electric vehicles assembled in the Latin American country (**Portal Movilidad, 2023**).

Other LMICs are also on the way to unlocking their potential as producers of ZEVs. Last year, South Africa published a roadmap for local production of ZEVs and ZEV components (**Government of South Africa, 2021**). In turn, Morocco has set out the target of producing 1 million EVs by 2025 (**ICCT, 2022a**).

Improved energy security is another major driver justifying a transition towards ZEVs. It boosts better end-use energy efficiency with respect to combustion technologies, and further energy efficiency benefits from forms of renewable electricity,[10] as solar and wind electricity production does not come with heat losses (occurring instead for thermal generation from fossil energy). It also promotes a far more diverse mix of primary energy to generate electricity cost effectively (**US DOE, n.d.**), in comparison to liquid fuels.

For oil importers, the combination of strengthened investment for road transport electrification and low-carbon electricity generation can also bring compelling gains, especially if paired with carbon pricing, relieving public finances and reducing their vulnerability to price shocks and supply scarcities (**World Bank, 2022**; **IEA, 2021a**).

CHALLENGES AND NEED FOR INTERNATIONAL COOPERATION

These opportunities come with major challenges, including access to investment, lack of visibility of potential socioeconomic development and risks of widening development inequalities, both between countries and between communities. The latter can happen due to gaps in capital availability (such as the existence of infrastructures) divides in governance and institutional quality and the availability of skilled labour (**ADB, 2010**), and disparities in the cost of capital, which tends to be higher in LMICs than in HICs (**IEA, 2023a**).

Discrepancies in per capita investments in energy and decarbonisation plans show the threat of a growing unequal world. In some cases, such as

investments in renewable energies, these imbalances continue to outgrow dramatically (**IRENA, 2023a**), putting the possibility of a net-zero world in jeopardy.

Strategies and technological advances to reduce reliance on certain minerals could also hinder the plans of mineral-rich countries to develop, dragging them to envisage a short-term economic gain and drain their interest in shifting to e-mobility (**Nurdiawati & Agrawal, 2022**). Minerals needed for the energy transition (an outstanding topic, both for EVs and for renewable energy supply) may also lead to a decarbonisation divide between producing and consuming countries (**EITI, 2022**).

Overcoming these challenges (along with other strategic, political and technical barriers) will be key to ensure an acceleration of the production and the demand of affordable and sustainable ZEVs. Scaling up efforts for stronger international co-operation to ensure a just and inclusive transition is a key part of the solution, in the interest of all stakeholders.

INTRODUCTION

Despite some progress in terms of market developments, significant challenges remain to ensure that the world can accelerate on the transition towards ZEVs[12] in a way that leaves no one behind.

The importance of assisting LMICs in devising policy strategies to enable a successful transition towards ZEVs was clearly identified in the GFEI's Zero Pathway report (**GFEI, 2021**). This is particularly important following the recent call to boost the investing capacity of MDBs to build a socially, environmentally and economically sustainable path forward, and to achieve the SDGs (**G20, 2022**).[13]

This report reviews the status of energy efficiency and decarbonisation policies for road transport, paying specific attention to measures related to ZEVs, low-carbon electricity and battery value chains. It builds on analyses reviewing ZEV policy frameworks in LMICs (such as (**ICCT, 2022a**), additional desk research, and inputs from a survey circulated among a wide range of stakeholders involved in energy efficiency in transport and ZEV policymaking.[14]

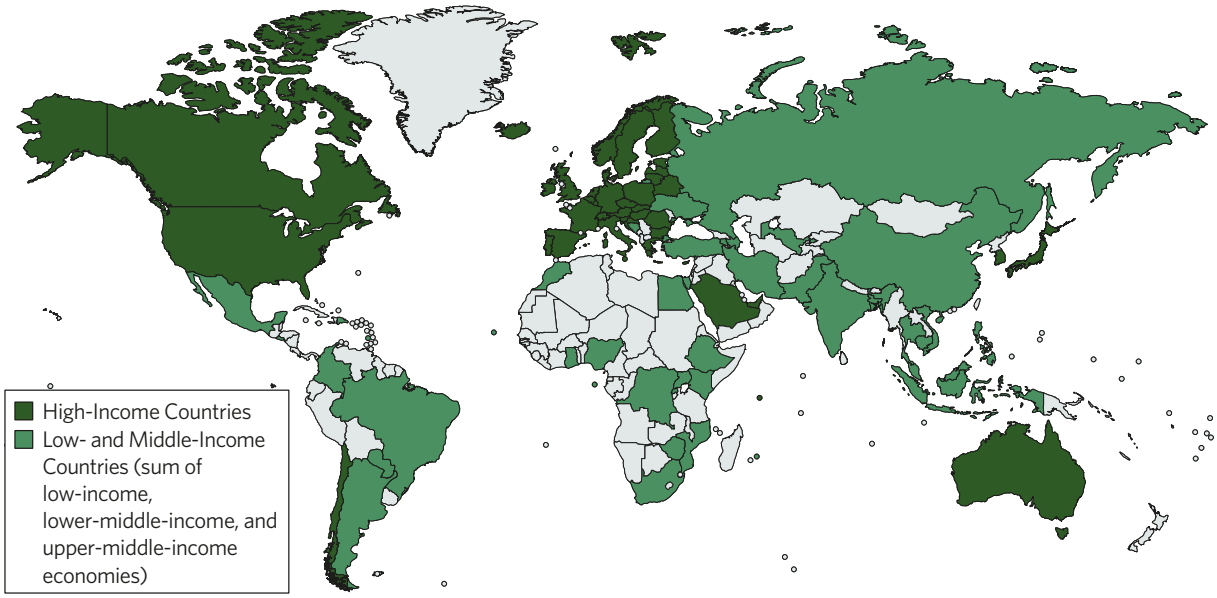
Drawing on country cluster analyses, it identifies topics for which increased availability of funding from MDBs and development agencies for a ZEV transition can be strengthened. The analysis also suggests how to structure technical assistance and coordination efforts to build capacity to receive and use these disbursements effectively, building on existing platforms of international cooperation.

GEOGRAPHICAL SCOPE

This work covers a vast set of countries shown in Figure 1.[15] **While the focus of the study is to analyse the ZEV transition in the Global South,[16] the geographical scope of the analysis aims to be global.** The assessment covers LMICs[17] in Africa, Eastern Europe, Latin America and the Caribbean, and Asia, as well as a selection of High-Income Countries (HICs) across the world.

The reason for including HICs in the analysis is two-fold: first, most of these have advanced and ambitious policies, which can provide a useful benchmark for the analysis; second, several policies in HICs are in a similar state to others in LMICs, or are countries of relevance in the supply chain of raw materials for ZEVs.

Figure 1. Countries and global regions covered in this study



Source: compiled by the authors.

More specifically, the geographical coverage of this analysis includes all members of the G20, the 20 most populated countries, signatories of the Acceleration to Zero Coalition[18] and a selection of other countries that have been supported by the GFEI over the years, including smaller vehicle markets in Africa, Latin America and Asia, encompassing a number of SIDS. The country coverage also reflects inputs, collected through a dedicated survey,[19] by specific policymakers in LMICs and members of the network of organisations working with GFEI and the ZEVTC.

The resulting selection of countries reflects a diverse mix of profiles, representing vast portions of the global population (85%), economy (92%)[20] and the four-wheeled vehicle market (97%).[21] Comparisons between these countries are intended to bring a perspective on the global state of the transition to ZEV.

SPECIFIC OBJECTIVES OF THIS ANALYSIS

This analysis aims to leverage lessons learnt from the GFEI community and its activities (including the findings of GFEI's Zero Pathway Report (**GFEI, 2021**)) to support the ambition of the ZEV Transition Council's International Assistance Taskforce (ZEVTC IAT) of enabling a 'faster, cheaper, and easier ZEV transition for all'.[22] It focuses specifically on the activities of the ZEVTC's Country Projects and Partnerships Working Group (CPPWG)[23] to ensure that no country or community is left behind. It does so by proposing priority areas of work for a more tailored, impactful, and effective offer of development assistance, providing evidence-based and action-focused recommendations on how and where the international offer can be strengthened.

The report intends to provide insights on existing challenges and opportunities to improve the effectiveness of development assistance funds to support, at once, ZEV adoption and local development in the Global South. These are not limited to lending operations and grants, but also include capacity building activities. This is because the latter are deemed necessary to ensure that financial support is paired with the goal of aligning developments in the road transport sector with sustainability requirements.

This assessment develops recommendations on a way to support LMICs to benefit from an accelerated transition towards ZEVs. As explained above, this is not only to capitalise on its health and environmental benefits, but also for increased opportunities to play an active part in the EV value chain. Given the relevance that EVs and low-carbon electricity will play in a carbon-constrained world, early moves towards the ZEV transition can foster the development of LMICs.

This analysis builds on countries' officials' opinions on what the priorities should be, both in the survey[24] and throughout the many years of working with GFEI. Key actions outlined in GFEI's Zero Pathway report and the Breakthrough Agenda report of 2022 (**Climate Champions, 2022**) also provide a foundation for this work. These include:

- Identifying critical requirements to accelerate global ambition to translate the Paris Agreement into action. Based on the Breakthrough Agenda report of 2022, these include investments in low-carbon electricity, ZEVs, low-carbon hydrogen and steel, and sustainable agriculture.
- Setting out a vision on how all countries can respond to the call by the United Nations (UN) Secretary-General to phase out sales of ICEVs in leading manufacturing countries by 2035 and globally by 2040.
- Laying out priorities for countries in different situations and contexts to achieve the trajectories needed to reach this global sales phase-out by 2040, in order to decarbonise vehicles by 2050.[25]
- Stressing the importance of an agreement on a shared understanding of the technologies that are consistent with the goal of zero-emissions road transport to send an unambiguous signal to the industry.
- Calling for the mobilisation of investments towards clean vehicles and clean energy, leveraging the development of regulations and clarifying which activities are aligned with sustainable finance requirements.
- Ensuring that sustainability and social responsibility along the entire electric vehicle battery supply chain fall within the scope of ZEV policy action, including the extraction and processing of minerals and improving the recyclability of battery modules.
- Underlining the importance of exchanges by governments of best policy practices, to mobilise investment and accelerate deployment of charging infrastructure, in consultation with vehicle manufacturers and infrastructure investors, and also flagging the importance to avoid further divergence of standards for charging infrastructure.

- Considering new and second-hand vehicles (of all types) to improve energy efficiency, enhance safety, prevent 'vehicle dumping', to avoid locking LMICs into higher emitting vehicles and to prepare the ZEV transition in a way that leaves no one behind.
- Flagging that, due to the complexity of the policy tools that shall accompany the ZEV transition, governments – especially LMICs – shall be effectively supported by capacity-building activities.

The GFEI's Zero Pathway report also indicated that not all countries are in the same position with respect to their transition towards ZEVs. It identified four types of country and vehicle markets that have their own pathways and are likely to be in different places in 2030. This would be especially relevant in the absence of capacity-building activities to facilitate the development of the complex policies needed to support and achieve a transition towards high ZEV shares in the road transport vehicle fleet. The categories considered in the mentioned report included leading markets,[26] close followers[27] and aggressive importers,[28] adding to a broad pool of remaining economies that had not yet taken proactive policy actions on energy efficiency and low-carbon vehicles.

This report takes this analysis a step further, organising countries in clusters, taking into account a range of different characteristics and crossing these with information that tracks policy progress on a selection of key priority areas for the ZEV transition.

The analysis develops a set of recommendations. These offer an opportunity to gain a clearer understanding of the policy steps needed to kick-off a ZEV transition, as a function of country situation and characteristics. The recommendations also outline workable pathways to accelerate the policymaking process, leveraging international cooperation opportunities and ultimately helping governments to gain access to increased amounts of financial support to foster climate action.

STRUCTURE OF THE REPORT

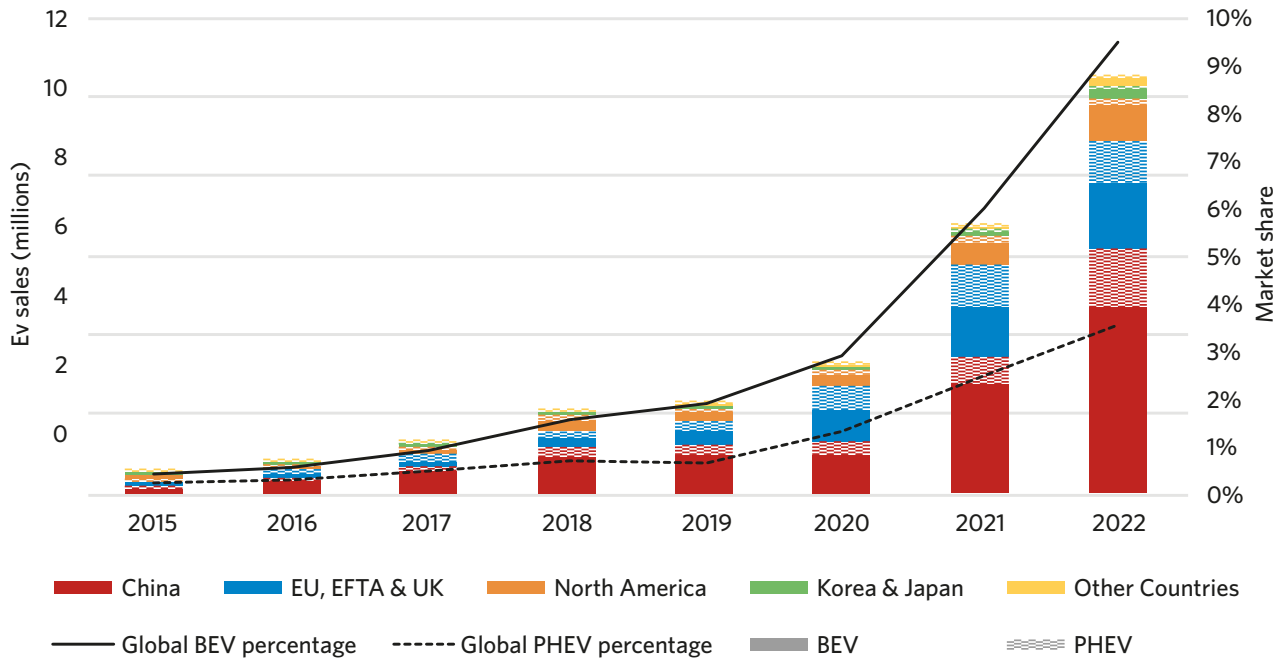
This assessment starts by providing a brief review of the status of the ZEV transition (Chapter 2). Chapter 3 refines the categorisation used in the GFEI's Zero Pathway report, clustering countries according to different indicators. Chapter 4 looks at the status of policy efforts in some of the key areas of the ZEV transition. The clustering exercise and the policy assessment are then combined in Chapter 5 to suggest ways to overcome challenges in areas where ZEV and ZEV-related policies are still subject to major gaps. This analysis informs a final section (Chapter 6) aiming to suggest a way forward for the organisation of mechanisms facilitating a transition that shall be fairer, faster, cheaper, and easier for all.

STATUS OF THE ZEV TRANSITION

Global electric car and light commercial vehicle sales[29] have more than tripled from 3.2 million in 2020 to 10.5 million in 2022 (Figure 2). Electric vehicles (BEVs and PHEVs) formed about 13% of the approximately 81 million new light vehicles sold globally in 2022 (**EV Volumes, 2023**; **Sundin, 2023**). The electric car sales shift has been driven by BEVs, which accounted for almost one out 10 vehicles sold globally in 2022 and represented nearly three quarters of the total of EVs. The remaining quarter consists of PHEVs, which reached 3.5% of total vehicle sales in 2022.

While EV uptake has shown a positive momentum worldwide, cars and light commercial vehicles are not the market segment where EVs reached the largest market shares. In 2022, two-wheelers and buses saw a higher EV penetration (essentially consisting of BEVs), as shown in Figure 3. Despite positive signals, the geographical distribution of ZEVs across the globe remains uneven.

Figure 2. Global electric car and light truck sales and shares, 2015-2022

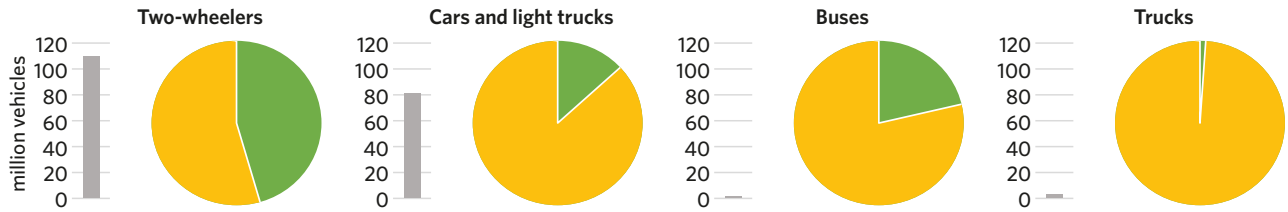


Source: ***EV Volumes, 2023***

For **two-wheelers**, the size of the global EV market is largely driven by the sales of about 50 million electric motorcycles and low-speed "bikes" sold in China.[30] This is complemented by an increasing amount (already exceeding half a million units) in India, dynamic sales in Vietnam, growing interest in other South-East Asian countries,[31] a promising momentum picking up in Europe (**MCD, 2023a**), and recent communications by Honda, the global leader in ICEV two wheeler sales, regarding its strategy for carbon neutrality (**Honda, 2022a**). In Latin America, despite being the second largest regional two-wheeler market, two-wheeler electrification is at an early stage (**ICCT, 2022a**). Meanwhile, Africa is seeing the emergence of several startups in the two- and three-wheeler segments. Several of these have been highlighted in Box 1, justifying the rationale of this report.

The global regions with the largest market shares of e-**buses** are China (roughly a quarter of all buses and minibuses) and Europe (close to 12%).[32] Chile and Colombia are home to the largest fleets of e-buses in the Global South after China. Thailand has 200 electric buses in stock, and Ukraine has 250 electric buses ordered. Others, such as Argentina, Brazil, Egypt, Malaysia, Türkiye, and South Africa have smaller e-bus stocks, but are developing pilot programmes and taking serious steps towards enhancing their deployment rapidly (**ICCT, 2022a**). India has announced the world's single largest procurement for 50,000 public electric-buses as part of a global grand challenge, leveraging aggregated public procurement strategies to reduce acquisition costs for e-buses (**CESL, n.d.**). This approach to demand aggregation has made e-buses now viable in India with or without subsidy support.

Figure 3. Global vehicle sales and shares in different vehicle segments, 2022



Source: estimates by the authors based on data available in ***Honda, 2022a; MCD, 2023b; ACEA, 2023a; ACEA, 2023b; China Buses, 2023; Steel Orbis, 2023; ICCT, 2022d; Sustainable Bus, 2023b; European Commission, n.d.b; Volvo Trucks, 2023; Sustainable Bus, 2023a; ICCT, 2022e; ICCT, 2023; JAMA, 2022; Yamada, 2023; Sae-ha & Lee, 2022; SMMT, 2023a; SMMT, 2023b; European Commission, n.d.c****. Note that two wheelers include items categorised as "electric bikes" by Honda. These have a speed limited to 25 km/h and complement "electric moped" (limited to 50 km/h) and "electric vehicles", closest to motorcycles.*

Significant differences in terms of EV adoption across global regions are also noticeable in the light vehicle segment, with only a fraction of electric **car and light commercial vehicle** sales occurring beyond Canada, China, Europe, Korea, Japan, and the US (as shown in Figure 3). In Asia-Pacific, China makes up about roughly 60% of the total light vehicle sales and more than 90% of all electric cars and light commercial vehicle sales in the region (**EV Volumes, 2023**). Without China, the Asia-Pacific region countries have a combined EV share of about 3%. In the Americas, including the US, Canada, Mexico, Chile, Brazil and Colombia (accounting for about a quarter of global light vehicle sales), the EV adoption reached about 6% in 2022. The US and Canada make up about 97% of the EV sales in the region (**EV Volumes, 2023**).

Electrification of highly-utilised vehicles (**taxis, ride hailing services, buses**) has a great decarbonisation potential, and it is already underway in a few countries who have introduced or are in the process of promoting electrification of taxis and ride hailing services. Chile, who continues to be the leader in ZEV deployment in Latin America and the Caribbean, is the only country with a 100% ZEV target for its taxi fleet in urban areas by 2035. South Africa has introduced e-ride hailing taxis, Ghana is taking up solar-powered taxis, and Ukraine has hundreds of EVs operating as ride hailing (**ICCT, 2022a**).

Given the disaggregated fleet sizes and operational nuances, and despite opportunities for cost effective savings for highly-utilised vehicle segments in urban environments, **electric trucks** are still in an early phase of market development, with low market shares in all global regions and with sales values that exceed 25,000 medium and heavy truck units in China (**Sustainable Bus, 2023a**). Low uptake of electric trucks, despite a growing potential for those used in urban environments, is consistent with the exclusion of this vehicle segment in ZEV policies in most countries, especially in the Global South. Only a few Latin American countries, such as Brazil and Colombia, registered sales of 1 to 31 BEV trucks in 2020 (**ICCT, 2022a**).

The low EV adoption in LMICs, observed in all segments (even though these markets contribute significantly to ICEV sales, due to growing vehicle ownership), is indicative of the challenge of decarbonising road transport in these markets. The key barriers to EV adoption in LMICs include low household incomes and limited affordability, limited access to finance and technology, lack of manufacturing capabilities and legacy investments, limited regulatory oversight and informality, especially in the public transport sector. These are more pronounced in countries that do not have assets in the automotive value chain and depend significantly on vehicle imports, both new and used vehicles (**Conzade, Engel, Kendall, & Pais, 2022**; **UNEP, 2020**).

Despite these challenges, LMICs can seize important opportunities from a global EV transition that is bound to continue over the next decades.[33] Arguments that support this idea include:

- Capacity to address the twin objectives of emission reduction and development, by creating new value chains in the economy through the e-mobility ecosystem.
- Significant shares of fleet vehicles with high rates of daily usage, including commercial two- and three-wheelers, taxis, buses and light commercial vehicles, as they benefit the most from lower operational costs, and provide the most important mobility services in the form of public transit and first / last-mile connectivity.

- Low power demand for electric two-wheelers, making them better suited for charging in locations with a grid infrastructure that is still being developed.
- Limited exposure to the asset stranding risks than those faced by HICs with a strong automotive sector, even if asset stranding challenges also exist in LMICs, especially if they have a vehicle manufacturing industry and are fossil energy exporters.
- Opportunities – also relevant for the transition of vehicle maintenance and servicing shops and eventually larger assembly facilities – from the repowering/repurposing of ICEVs into BEVs, through retrofits.[34]
- A forward-looking investment environment (also due to the expectation of a dynamic growth of vehicle demand, especially for small and affordable options) for start-ups capable of designing and assembling vehicles (from two and three-wheelers to buses) with cost and durability features in line with the nature of the demand that characterises LMICs markets (**Conzade, Engel, Kendall, & Pais, 2022**).

Opportunities for countries with an existing automotive manufacturing base to reorient themselves in the global value chain with the EV transition, and provides additional economic opportunities for countries with a high level of endowment in critical raw materials for EVs.

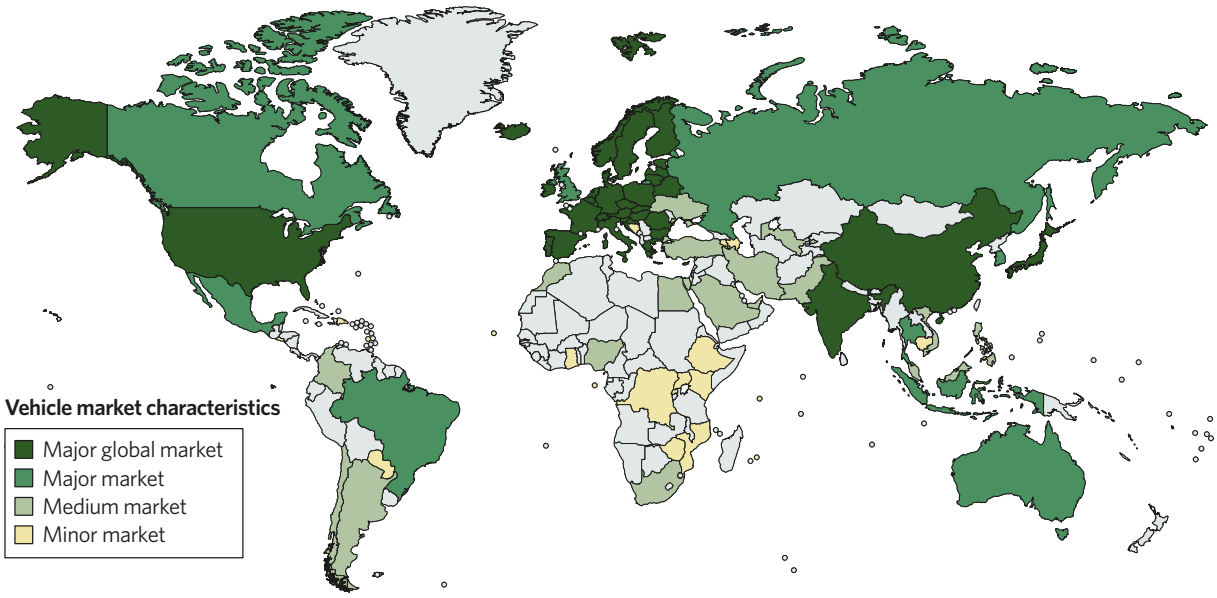
COUNTRY CLUSTERING CRITERIA

This section refines the categories of countries considered in the GFEI's Zero Pathway report (**leading markets, close followers, aggressive Importers and others**) by looking into a set of possible clustering criteria to better define strategies for LMICs to transition towards ZEVs. These criteria, combined with the policy review outlined in the next chapter, are then used as the basis to suggest a way forward in the development of capacity-building activities that need to complement the mobilisation of investments and the channelling of development support funds towards clean vehicles and clean energy.

A first indicator helping with the identification of more refined country clusters represents the **vehicle market characteristics**, differentiating global economies on the basis of the total number of vehicles sold in each of them (Figure 4). This is the result of the combination of country size, motorisation rates and the existence of free trade agreements. It shows the greatest concentrations in the US, Europe, China, India and South-East Asia, followed by Latin America (Mercosur, in particular Brazil and Argentina), Australia, the Russian Federation and the United Kingdom (UK). Markets in the Middle East, Central Asia and Africa are characterised by smaller sizes, both on the individual and the regional level.

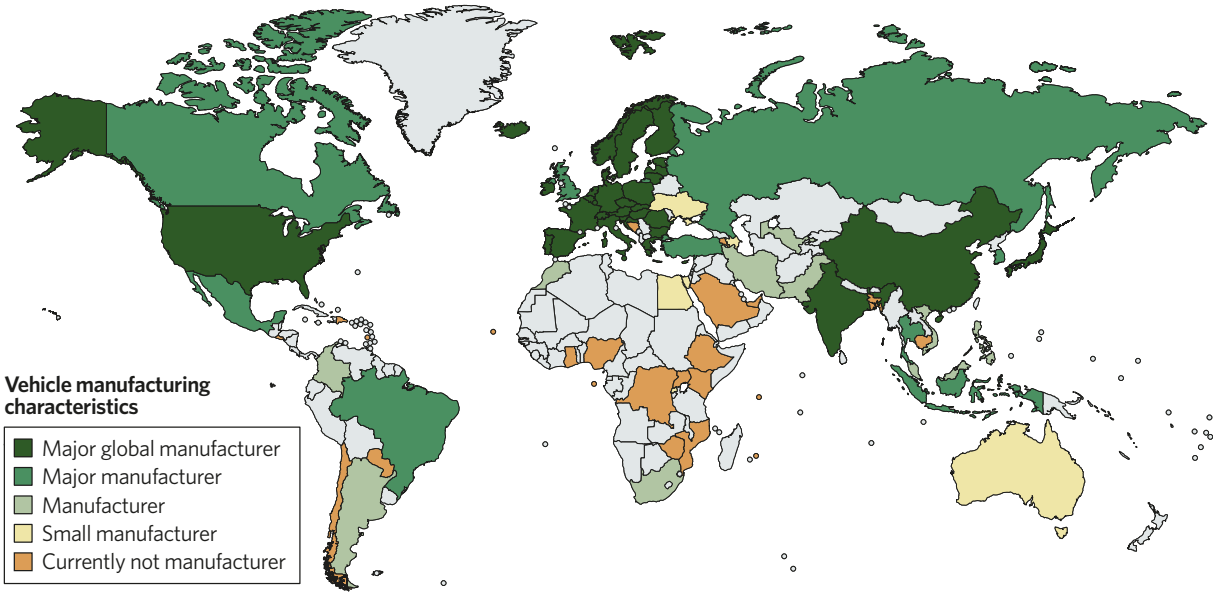
A second indicator, represented in Figure 5, relates with the **vehicle manufacturing capacity** (with a focus on cars and heavy duty) of different countries. To a good extent, this mirrors the size of the vehicle markets and sees major economies like China, India, the EU and EFTA, Mexico and the US as major players. Other important vehicle manufacturing countries include Brazil, Türkiye and the Russian Federation. Morocco and South Africa are the countries with manufacturing capacity in Africa; Iran, Pakistan and Uzbekistan have manufacturing capacity in Central and South Asia. Argentina and Colombia have some vehicle manufacturing capacity in Latin America. Chile and Saudi Arabia, despite being medium sized vehicle markets (more than 400 thousand and 550 thousand new vehicles sold per year, respectively), have no vehicle manufacturing activities, to date.[35]

Figure 4. Country characterisation based on vehicle market size



*Source: compiled by the authors, based on data from **OICA, 2023a** on vehicle sales and complementary information for countries not individually represented in the OICA database. Lower thresholds identifying different market sizes are set at 3 million units for major global markets, 1 million for major markets and 50 thousand units for medium markets.*

Figure 5. Country characterisation based on their vehicle manufacturing capacity

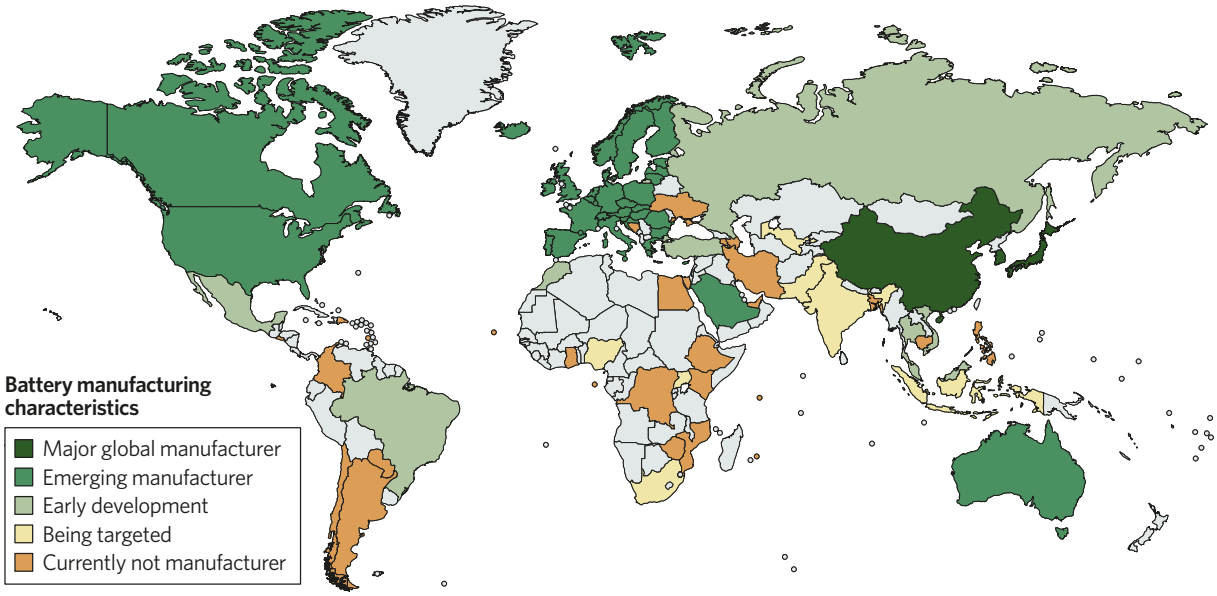


*Source: compiled by the authors, based on data from **OICA, 2023b**. Thresholds identifying market sizes are set at 3 million units for major global manufacturers, 1 million for major manufacturers, 50 thousand units for manufacturers. Countries with no mass production of vehicles are qualified as non-manufacturers, the remaining ones as small manufacturers.*

A third set of indicators reflects the role of the countries considered in **battery manufacturing** (Figure 6) and **related supply chains** (Figure 7). These highlight that there is a clear primacy of China, Korea and Japan in battery manufacturing, despite increasing activities in Australia, Europe, US, Canada, Saudi Arabia and, to some extent, in other countries with vehicle manufacturing capacity (e.g. Malaysia, Mexico, Thailand). Argentina, Australia, Brazil, Chile, the Democratic Republic of Congo (DRC), Indonesia and South Africa are prominent players in the battery supply chain (mining and processing industries), largely due to their high endowment in the minerals needed for battery manufacturing. Russia is classified as a key player in the battery supply chain, due to its relevance for battery minerals and mining activities from Nickel endowments (**McNulty & Jowitt, 2021**), but this is currently impacted due to the ongoing geo-political conflict between Russia and Ukraine (**Hockenos, 2022**).

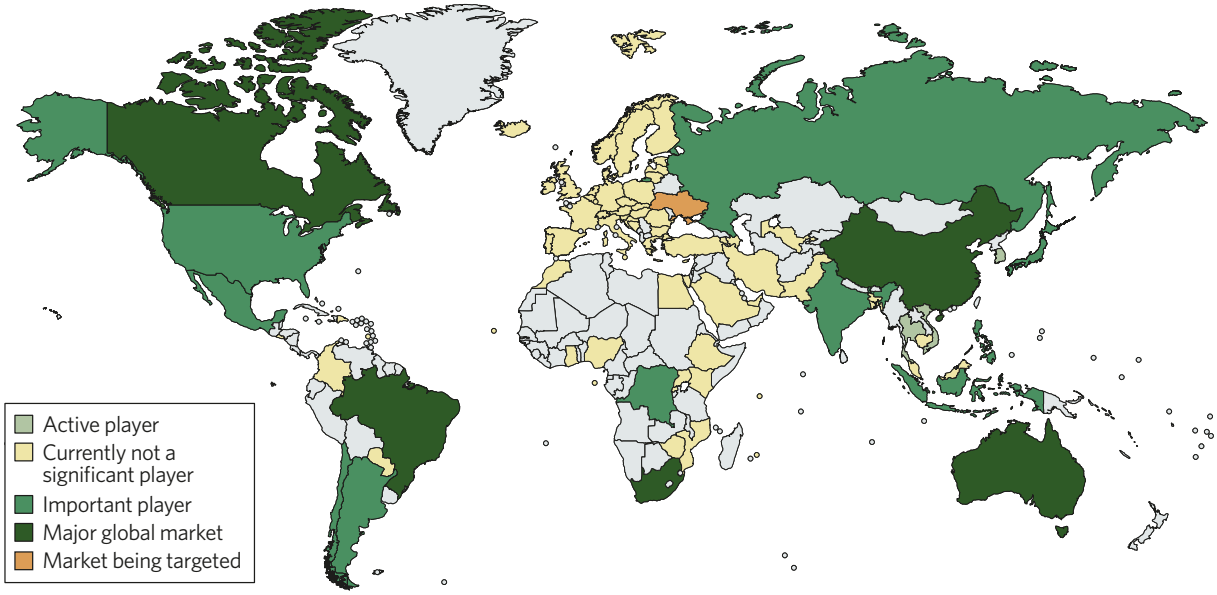
Countries can also be clustered on the basis of the **carbon intensity** of the electricity mix, a parameter that not only has relevance to reduce operational emissions from EVs, but is also an important determinant of emissions from manufacturing (especially in cases where the production of aluminium – an important determinant of the carbon intensity of battery manufacturing – is also taking place in the same geography). Figure 8 shows results linked to this indicator, pointing to significantly greater carbon intensities in countries located in Asia, currently more reliant on coal, along with South Africa, and in the Middle East, more reliant on fossil hydrocarbons. The same figure also points to significantly lower carbon intensities in countries highly reliant on hydropower, in Central Africa and Latin America, and in HICs with a diversified electricity supply, with growing shares of renewable energy in the mix.

Figure 6. Country characterisation based on their battery manufacturing capacity



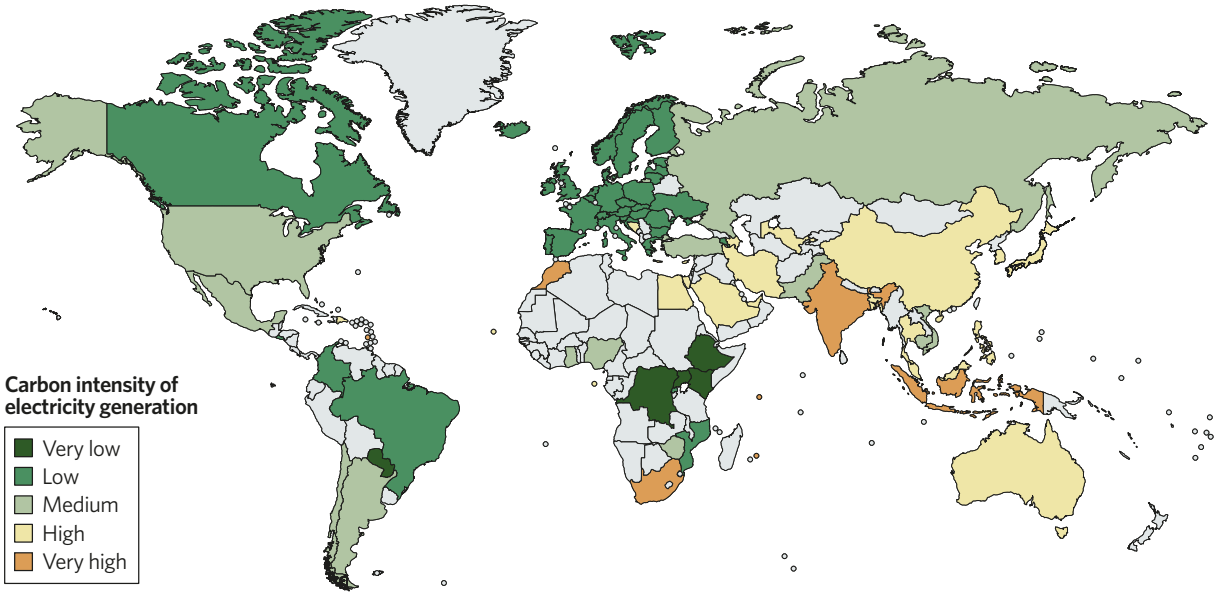
Source: compiled by the authors, based on data from ***Bloomberg NEF, 2020; Bhutada, 2021; McNulty & Jowitt, 2021*** *and* ***IEA, 2023c****, complemented by information from* ***Aine, 2022; APP, 2022; Daryo, 2022; Eljechtimi, 2022; Fitch Solutions, 2022; Fox, 2022; Grimes, 2023; Huber, 2022; Jennings, 2022; Kane, 2022; Kane, 2023; Murtaugh, 2023; Phoonphongphiphat, 2022; Rabson, 2022; Sudhakar, 2022; Tyagi & Warrior, 2023.***

Figure 7. Country characterisation based on their presence in the battery supply chain



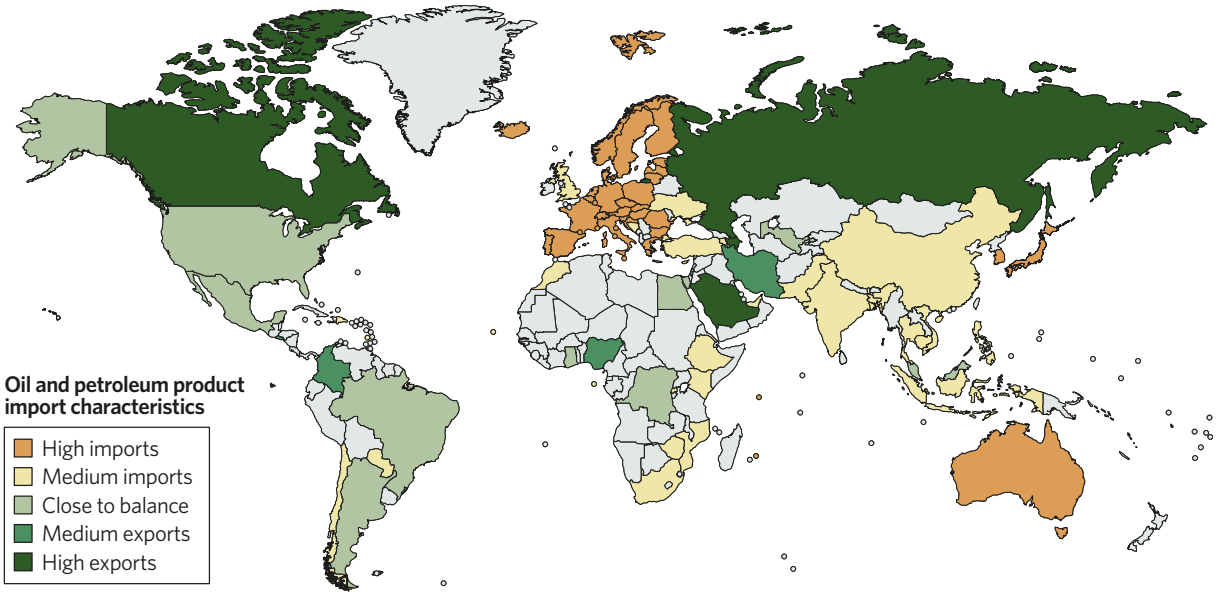
Source: compiled by the authors, based on data from ***Bloomberg NEF, 2020; Bhutada, 2021; McNulty & Jowitt, 2021*** *and* ***IEA, 2023c****, complemented by information from* ***Aine, 2022; APP, 2022; Daryo, 2022; Eljechtimi, 2022; Fitch Solutions, 2022; Fox, 2022; Grimes, 2023; Huber, 2022; Jennings, 2022; Kane, 2022; Kane, 2023; Murtaugh, 2023; Phoonphongphiphat, 2022; Rabson, 2022; Sudhakar, 2022; Tyagi & Warrior, 2023; Tyagi, et al., 2023.***

Figure 8. Country characterisation based on carbon intensity of electricity generation



*Source: compiled by the authors, based on data from **EMBER, 2022**. Thresholds are set at 600 g CO_2/kWh for very high carbon intensity, 450 g CO_2/kWh for high intensity, 350 g CO_2/kWh for medium intensity, and 100 g CO_2/kWh for low intensity.*

Figure 9. Country characterisation based on their oil and petroleum product trade



*Source: compiled by the authors, based on data from IEA energy balance tables, accounting for net trade of oil and petroleum products, combined (**IEA, 2022c**). Key thresholds are 50 PJ/million people for high imports (or exports) and 10 PJ/million people for medium imports (or exports). This classification also accounts for countries closer to a zero balance of the relative importance of net imports per unit of economic activity.*

One more parameter that reflects a key driver for countries to have interest in ZEVs is their net **balance in terms of trade of oil and petroleum products**. Figure 9 illustrates this and points clearly to significant disparities across the globe. Canada, the Russian Federation, Saudi Arabia and the United Arab Emirates (UAE) are the main net oil exporters per capita, followed by Colombia, Iran and Nigeria. Australia, the EU and EFTA, Korea and Japan, on the other hand, have among the highest rates of imports per capita. Similar conditions are shared by SIDS like Mauritius and Cabo Verde. Major Asian countries like China, India and Indonesia; South Africa, Morocco and East African countries, and Türkiye and Ukraine in the Eurasian region, are net importers of oil and petroleum products. Key Latin American (Argentina, Brazil) and African countries (DRC, Ghana) are amongst the net oil exporters.[36]

USE OF COUNTRY CLUSTERS IN THE FOLLOWING ANALYSIS

The set of indicators developed above, combined with an assessment of the status of policy action in the countries considered by this analysis (developed in Chapter 4), will be instrumental for the analysis of remaining policy gaps and the development of recommendations for support mechanisms, in line with the objective to enable a transition to ZEVs that is affordable, sustainable and timely.

Priorities for policy action identified in the GFEI's Zero Pathway report apply universally and are relevant for all country clusters that can be identified through the indicators suggested above, irrespective of their role in manufacturing value chains, as highlighted in Table 1.

The reasoning outlined in the Table applies independent of carbon intensity in electricity production, since countries with a carbon intensity that is already low can seize greater opportunities for access to major market, in addition to an alignment with environmental policy objectives, while a transition for the others is environmentally sound and also an enabler of better market access, given that HICs are progressively requiring an alignment of products with sustainability requirements.

The analysis summarised in the Table also refers to both oil/petroleum product importers and exporters. For importers, energy security advantages are larger, and they add to improvements in the trade balance, especially if electricity can be locally produced. For exporters, it is important to anticipate the ZEV transition due to the relevance that changes taking place at the global scale will have on their economic resilience, requiring increased diversification of their economies, making them less dependent on oil and gas revenue (***IEA, 2018a***).

All policies listed in Table 1, already identified in the GFEI Zero Pathway report, are likely to be good candidates for capacity building activities in countries that are not part of the *leading markets* and *close followers* (mostly HICs) also identified in the same report. The following sections will provide evidence that this support is especially relevant for LMICs, which, despite relevant opportunities, had less chances, to date, to take proactive policy action on energy efficiency and ZEVs, in part due to greater barriers in capital availability (something that development aid can be instrumental to address).

TABLE 1. RELEVANCE OF ZEV-RELATED POLICY INSTRUMENTS FOR COUNTRIES IN DIFFERENT CLUSTERS

Policy Instrument	Relevance for			
	Countries with vehicle manufacturing capacity*	**Countries with battery manufacturing capacity***	**Countries without vehicle manufacturing capacity***	**Countries without battery manufacturing capacity***
Policies promoting vehicle electrification	Yes, for environmental reasons, industrial/economic/ social development, affordability and energy security		Yes, for environmental reasons, affordability and energy security	
Policies promoting the roll out of charging infrastructure, also avoiding further divergence of technical standards	Re-skilling policies related with the job transition		Yes, for environmental reasons, affordability and energy security	
Policies promoting the diversification of investments towards the BEV/battery and mineral processing value chain	Yes, as they could help attracting investments in new value chains, favouring industrial/economic/social development			
Measures aligning upcoming investments on batteries and related supply chains with sustainability requirements	Yes, as they as they would help foster the alignment of products with sustainability requirements and ensure/improve access to major global markets		Yes, as they would help foster the alignment of products with sustainability requirements	
Policies promoting fuel economy improvements	Yes, both for environmental reasons and industrial/economic/ social development		Yes, for environmental reasons, affordability and energy security	
Coordinated measures to structure international trade of second-hand vehicles	Yes, both for environmental reasons and industrial/economic/ social development		Yes, for environmental reasons and energy security, despite the need to seek a balance with affordability challenges	
Policies promoting increased transparency of information on the alignment with sustainability requirements	Yes, for environmental reasons and industrial/economic/social development, including due to improved access to major global markets			
Carbon pricing policies	Yes, for environmental reasons and industrial/economic/ social development and to ensure the economic sustainability of the transition			
Transition towards road charges	Yes, to ensure the economic sustainability of the transition			
Electricity market reforms	Yes, for environmental reasons and industrial/economic/ social development and to ensure the economic sustainability of the transition			
Re-skilling policies related with the job transition	Yes, for environmental reasons and industrial/economic/social development and to ensure the economic and social sustainability of the transition		Yes, as they could help attracting investments in new value chains, favouring industrial/economic/ social development	

** Or plans to have a presence in the value chain in the future.*

Source: compiled by the authors.

STATUS OF THE ZEV POLICY ACTION

This chapter outlines the status of global action on ZEV policies. It draws on desk research, complemented by information received through a dedicated survey[37] answered by around 110 policymakers in LMICs and members of organisations working with GFEI and the ZEV Transition Council (ZEVTC).

The chapter covers key policy areas, including:

- The enhancement of fuel economy for road transport vehicles (also integrating some information regarding second-hand vehicle trade).
- A progressive transition towards ZEVs and the deployment of charging infrastructure.
- The sustainable production, use, disposal and recycling of EV batteries.
- A progressive transition towards low-carbon electricity production.

The analysis of each policy area starts with a table and figure characterising the status of specific policies at the national level, in the selection of countries outlined in Chapter 1. The following discussion provides details on the information summarised in Table 1 and Figures in Chapter 3. Policies are assessed taking into consideration different degrees of ambition (e.g. related with vision statements/targets, roadmaps, proposals, fiscal measures and regulatory requirements).

The analysis ranks the status of policies across five categories, according to the following scales:

- The policy ranks **'Having sound policies in place'** if it has already been approved (i.e. in the form of a law or mandate), includes significant ambition and is part of a comprehensive set of coordinated measures.
- **'Having policies in place, to some extent'** means that there is a policy in place, but coverage is insufficient or not as ambitious as in the case above (e.g. in case there is a differentiated taxation, based on environmental performance, but this is not paired with regulatory requirements).
- **'Developing policies'** is the category for plans or roadmaps that have not yet been translated into action (e.g. when a country has committed to or signed a legally-binding provision, both nationally or as part of a global, international ambition, that obliges it to improve the energy efficiency of transport vehicles in the short-medium term).
- **'Not having policies in place, nor developing them, but considering them'** responds to the category where a country has announced that it will start drafting a policy, or a roadmap that foresees the introduction of the policy in question (e.g. the introduction of fuel economy vehicle standards).
- Finally, **'Not having policies in place, neither developing them, nor considering them'** has been assigned in cases where nothing, not even an official announcement, has been found mentioning the intention to develop a policy promoting a transition towards ZEVs.

POLICIES REQUIRING THE ENHANCEMENT OF FUEL ECONOMY FOR ROAD TRANSPORT VEHICLES

Figure 10 summarises the status of policies requiring fuel economy improvements for transport vehicles. Results reflect not only the ambition in terms of policy requirements (degree of energy efficiency improvement, timeline), but also the modal coverage (e.g. whether this is limited to light vehicles, or also targeting heavy vehicles or two/three-wheelers). Countries or global regions that are qualified as "having sound policies in place" have established fuel efficiency standards, covering at least light vehicles. Countries having complementary measures limited to vehicle and fuel taxation[38] are qualified as "having policies in place, to some extent". Countries qualified as "developing policies" have established processes meant to lead to the adoption of fiscal or regulatory requirements or at least instrumental for them (such as fuel economy measurement and the integration of information related with environmental performances in vehicle registries). Other countries are either considering the development of these measures, or not yet doing so.

Countries that adopted policy packages with greater ambition (i.e. including regulatory requirements, although not all with the same level of stringency) and clear links with CO_2 emissions or energy efficiency as the criteria to define their policies include Brazil, Canada, Chile, China, the EU and EFTA, India, Japan, Korea, Mexico, Saudi Arabia, the UAE, the UK and the US. All of the countries having adopted these policies, except Brazil, Chile, India and Mexico, are HICs. Most of them are major vehicle markets (in terms of sales). No small vehicle market is part of this group. Almost all countries host a vehicle manufacturing industry with sizeable production capacity.

China is the only country in this group that adopted

Figure 10. Summary of policies promoting fuel economy improvements for transport vehicles

Country	Policy	Country	Policy	Country	Policy	Country	Policy	Country	Policy
Argentina		China		Iran		Paraguay		United Arab Emirates	
Armenia		Colombia		Japan		Philippines		Uganda	
Australia		Dominican Republic		Kenya		Russian Federation		Ukraine	
Azerbaijan		Democratic Republic of Congo		Korea		Rwanda		United Kingdom	
Bangladesh		Egypt		Malaysia		São Tomé and Príncipe		United States	
Bosnia and Herzegovina		El Salvador		Mauritius		Saudi Arabia		Uzbekistan	
Brazil		Ethiopia		Mexico		Seychelles		Vietnam	
Cabo Verde		EU and EFTA		Morocco		South Africa		Zimbabwe	
Cambodia		Ghana		Mozambique		St. Lucia			
Canada		India		Nigeria		Thailand			
Chile		Indonesia		Pakistan		Türkiye			

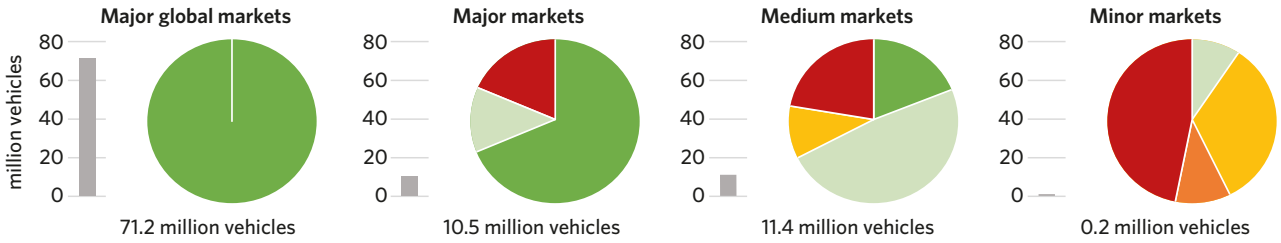
Having sound policies in place

Having policies in place, to some extent

Developing policies

Not having policies in place, nor developing them, but considering them

Not having policies in place, neither developing them, nor considering them



Source: compiled by the authors, based on ***GFEI, 2020; IEA, 2022d; IEA, 2021c; Clean Air Asia, 2022; IEA, 2022h; ITF, 2022; ICCT, 2022b; van Laake, Lozano, & Gillod, 2021; UNFCCC, 2020; Climate Action Tracker, 2022b; Government of Ghana, n.d.; Government of India, n.d.; IEA, 2020a; UNEPCCC, 2020; Diario Oficial, 2013; Electricidade de Moçambique, 2021; Government of Nigeria, n.d.; Government of Pakistan, n.d.; Government of Paraguay, 2014; Se4All, 2016; GN SEC, 2022; IEA, 2021f; Al Wasmi, 2016; Energy Efficiency Fund, n.d.; IEA, 2022i; IEA, 2022e; UNFCCC, 2021c; Transport Policy Net, n.d.;*** *survey responses,* ***OICA, 2023a*** *on vehicle sales and complementary information for countries not individually represented in it.*

Notes: EU = European Union; EFTA = European Free Trade Association. Major global markets include China, the European Economic Area (plus Switzerland), India, Japan and the United States. Major markets include Australia, Brazil, Canada, Indonesia, Korea, Mexico, Russia, Thailand and the United Kingdom. Medium markets include Argentina, Chile, Colombia, Egypt, Iran, Malaysia, Morocco, Nigeria, Pakistan, Philippines, Saudi Arabia, South Africa, Türkiye, the United Arab Emirates, Ukraine, Uzbekistan and Vietnam. Minor markets include Armenia, Azerbaijan, Bangladesh, Bosnia and Herzegovina, Cabo Verde, Cambodia, Dominican Republic, the Democratic Republic of Congo, El Salvador, Ethiopia, Ghana, Kenya, Mauritius, Mozambique, Paraguay, Rwanda, São Tomé e Principe, Seychelles, St. Lucia, Uganda and Zimbabwe. Grey shading in the table is used for HICs.

fuel economy standards across all vehicle types, including two-wheelers, cars and heavy vehicles. Canada, the EU, Japan, Mexico, the UK and the US have adopted regulatory requirements for both cars and heavy vehicles. India has particulate emission standards for heavy vehicles and fuel economy standards for this vehicle type are in a draft stage. Other countries only focused on cars and light trucks (or light commercial vehicles).

Countries with a lower policy ambition, excluding regulatory measures to promote energy efficient vehicles, include Argentina, Bosnia and Herzegovina, Colombia, Indonesia, Malaysia, Mauritius, Morocco, Pakistan, South Africa, Thailand, and Türkiye. These countries adopted at least an energy efficiency labelling framework, and in most cases (exceptions are Argentina and Mauritius) also paired it with differentiated taxation or incentives for fuel efficient vehicles. Key indicators used for differentiated taxation may still be based on engine size and/or power. Türkiye does not have standards, but has fuel taxes amongst the highest globally and a market closely linked to the EU. Many of these countries have significant manufacturing capacity (Argentina, Colombia, Indonesia, Malaysia, Morocco, Pakistan, South Africa and Türkiye), some are vehicle exporters, but none is a major global automotive manufacturer.

The third set of countries (developing policies) includes Armenia, Bangladesh, Kenya, Philippines, Rwanda, Seychelles, Saint Lucia, Uganda, Vietnam and Zimbabwe. In these cases, research and/or survey results pointed to weaker policy frameworks, revealing interest in the topic but limited ambition or the lack of a clear desire to target fuel economy. Selected examples include guidance documents for fuel economy labelling (as in the case of the Philippines), accompanied by excise taxes on vehicles that are differentiated based on vehicle price (**ITF, 2022**). Armenia is an interesting case, as it is expected to align with EU efficiency standards for transport vehicles between 2026 and 2030 as part of the Comprehensive and Enhanced Partnership Agreement (CEPA) provisions (**IEA, 2022d**). Kenya has the goal to reach an average fuel consumption for light vehicles of 6.5 L/100km and average CO_2 emissions of 160 g/km by 2025 (**Government of Kenya, 2020**) and it is also enforcing a maximum age limit of 8 years for used car imports (**IEA, 2022e**). These countries are all amongst LMICs, very few have a vehicle manufacturing industry, and none is a major automotive market.
Countries in remaining categories are characterised by policy frameworks that may include energy efficiency amongst their goals, possibly also mentioning road transport, but do not get into substantial implementing actions. Australia is an interesting case, as it is the only HIC amongst those considered that does not have fuel economy policies. The country does not have a sizable automotive manufacturing industry but could benefit from fuel economy policies, as it is a net importer of oil and/or petroleum products. Other countries are all LMICs, medium or small markets, and generally open to import second-hand vehicles (refer to Box 2), most likely for reasons related to lack of domestic industry capacity and affordability. Ghana has been working with the GFEI network to start acting on fuel economy (**GFEI, 2020a**), and São Tomé and Príncipe mentions energy efficiency vehicle standards in its National Energy Efficiency Action Plan (**Government of São Tomé and Príncipe, 2022**).

POLICIES AIMING TO SUPPORT THE DEPLOYMENT OF EVS AND CHARGING INFRASTRUCTURE

Governments are developing varied strategies to encourage the adoption of ZEVs ranging from fuel economy and emission regulations to economic incentives such as purchase subsidies. Other policy measures specific to ZEVs lie on the supply side to stimulate industrial development. Complementary policies also aim to enhance the deployment of charging infrastructure, as the parallel development of infrastructure and EVs has been a crucial pillar of the dynamics of the EV deployment in countries that have already achieved a successful transition towards e-mobility.

Figure 11 summarises the state of policies and roadmaps supporting ZEV deployment, while Figure 12 focuses on the deployment of charging infrastructure, broadly indicating that there may be some delay in the development of policy tools specifically focusing on access to charging. As a general rule, countries that made progress on vehicle policies also worked on infrastructure deployment. Table 2 summarises existing policy frameworks and related sources of information, giving transparency on what underpins this analysis.

The subset of eight countries/global regions with the most comprehensive ZEV deployment and charging infrastructure policies include Canada, China, the EU/EFTA, India, Korea, Japan, the UK, and the US. Other economies with policies in place for ZEV and charger deployment are Mexico and Thailand. Most of these are HICs, and only a fraction are LMICs. All of them are major vehicle markets (in terms of

Box 2. International trade of second-hand vehicles

Despite challenges on the availability of data on second-hand vehicle trade, available estimates point to significant amounts (close to 4/5 million units a year between 2015 and 2020) of light vehicles. Roughly two thirds of these are moved from HICs (mainly the EU, Japan, Korea and the United States) to LMICs. Africa received the highest share of exports (25%), followed by Eastern Europe, Caucasus, and Central Asia (about 14%), Asia-Pacific (12%), the Middle East (10%), and Latin America and the Caribbean (8%) (**UNEP, 2021**).

Countries excluded from these trade flows are generally major manufacturers that adopted a complete ban on second hand vehicle import, largely to protect their own manufacturing industry (**UNEP, 2020**). Actual trade is affected by different types of restrictions, including age limits trying to strike a balance between vehicle safety and environmental performance and the possibility to enable increased motorisation at a lower cost. Additional motorisation management policies for used vehicles, including safety tests, emissions requirements, or financial levers (such as differential tariffs based on vehicle characteristics or age) also add to regulatory restrictions. In 2021 the United Nations Environment Programme (UNEP) reviewed the regulations that govern second-hand vehicle imports for 146 countries and found that about 45% had weak or very weak regulations, and 42% had good or very good regulations (**UNEP, 2021**).

Trade occurs for many reasons, including high import tariffs on new vehicles (for reasons related to the management of the trade balance), affordability limitations of LMICs, interest in bridging end-of-life vehicle management obligations in HICs. Lower repair costs in LMICs and poor enforcement conditions can also lead to trade of vehicles that no longer meet safety or environmental regulations.

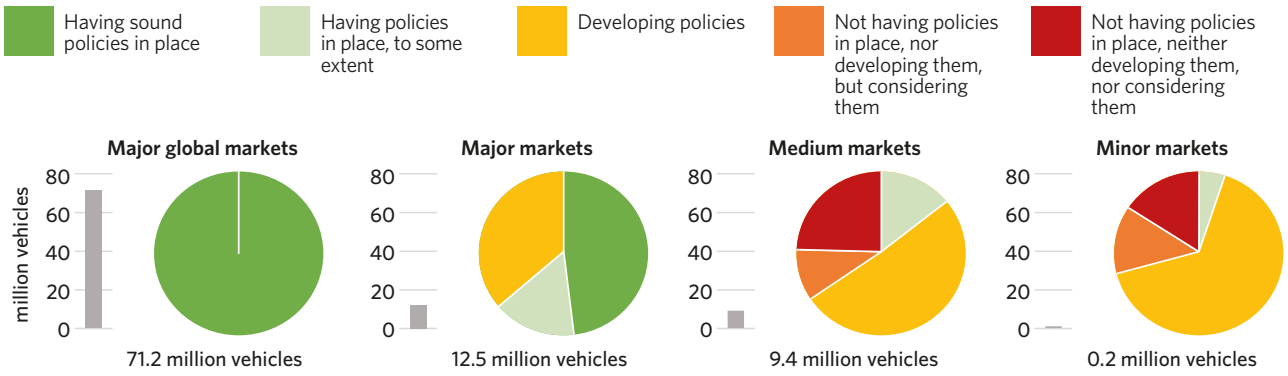
The vast majority of second-hand vehicles traded internationally are used ICEVs (**UNEP, 2020**), but there have been cases (in particular Sri Lanka) deliberately favouring flows of second-hand hybrid vehicles, for energy efficiency and environmental reasons. Further developments may also attempt to focus on EVs. Examples exist already today, in Egypt or El Salvador. Egypt has given a 100% custom exemption to EVs that are less than three years old, despite a countrywide ban on importing used vehicles since 2013 (**UNEP, 2020**). El Salvador has forbidden imports of EVs whose date of manufacture is more than three years old (**Government of El Salvador, 2020**).

Due to material availability constraints and circular economy policies, it is possible - if not likely - that second-hand trade of ZEVs towards receiving markets is delayed or reduced in volumes. This may add to a new set of quality and safety challenges (**ICCT, 2022a**). However, if EVs are eventually imported in LMICs, they will likely die there (**GFEI, 2020b**). To prevent the 'dead-battery dilemma' from happening (**Sarpong, 2023a**), it is critical that countries develop policies that support the sustainable repurposing and disposal management of EV parts, such as batteries, as well as addressing other end-of-life issues.

Key measures that could help prevent this development are in the same category of those that can help manage ICEVs trade. They include improved information about vehicle conditions, improved vehicle export and import controls/ inspections. Better technical information for repair and repurposing of batteries is also instrumental to prevent second-hand electric vehicle or second-hand battery exports from becoming a least-cost disposal option for exporting markets, burdening rather than benefiting the importing markets (**Kendall et al., 2023**). Taking a regional approach to support greater harmonisation in policies through multilateral organisations (e.g. Mercosur, ECOWAS, etc.) could also play an important role in this space.

Figure 11. Summary of policies supporting a progressive transition towards ZEVs

Country	Policy	Country	Policy	Country	Policy	Country	Policy	Country	Policy
Argentina		China		Iran		Paraguay		United Arab Emirates	
Armenia		Colombia		Japan		Philippines		Uganda	
Australia		Dominican Republic		Kenya		Russian Federation		Ukraine	
Azerbaijan		Democratic Republic of Congo		Korea		Rwanda		United Kingdom	
Bangladesh		Egypt		Malaysia		São Tomé and Príncipe		United States	
Bosnia and Herzegovina		El Salvador		Mauritius		Saudi Arabia		Uzbekistan	
Brazil		Ethiopia		Mexico		Seychelles		Vietnam	
Cabo Verde		EU and EFTA		Morocco		South Africa		Zimbabwe	
Cambodia		Ghana		Mozambique		St. Lucia			
Canada		India		Nigeria		Thailand			
Chile		Indonesia		Pakistan		Türkiye			



Source: compiled by the authors based on ***Commonwealth of Australia, 2022; Rahman, n.d.; Brazilian Chamber of Deputies, 2020; IEA, 2022h; Kak, 2022; Government of Canada, 2022a; Government of China, 2020; Government of Colombia, 2019; UNFCCC, 2021d; Climate Action Tracker, 2022b; Government of El Salvador, 2020; EfD, n.d.; GFEI, 2020a; ITF, 2022; IEA, 2020a; Government of Japan, 2020; Kenya Power, 2022; Government of Mexico, 2018; UNFCCC, 2022d; Government of Mozambique, n.d.; Dioha & Caldeira, 2022; Government of Pakistan, 2019; Government of Paraguay, n.d.; UNEP, 2022b; ALER, 2022b; CMS, n.d.; Government of Seychelles, 2022; Government of South Africa, 2021; Government of Dubai, 2020; CIG, 2021; Government of Ukraine, n.d.; Government of the United Kingdom, 2022b; US Department of Transportation, n.d.; UNEPCCC, 2022b;*** *survey responses* ***OICA, 2023a*** *on vehicle sales and complementary information for countries not individually represented in it.*

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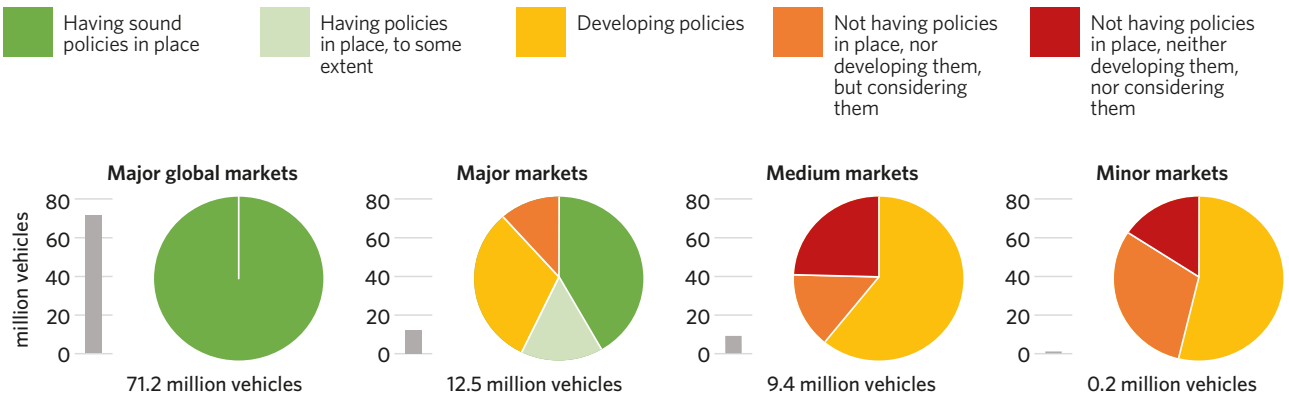
Figure 12. Summary of policies targeting the deployment of charging infrastructure

Country	Policy	Country	Policy	Country	Policy	Country	Policy	Country	Policy
Argentina		China		Iran		Paraguay		United Arab Emirates	
Armenia		Colombia		Japan		Philippines		Uganda	
Australia		Dominican Republic		Kenya		Russian Federation		Ukraine	
Azerbaijan		Democratic Republic of Congo		Korea		Rwanda		United Kingdom	
Bangladesh		Egypt		Malaysia		São Tomé and Príncipe		United States	
Bosnia and Herzegovina		El Salvador		Mauritius		Saudi Arabia		Uzbekistan	
Brazil		Ethiopia		Mexico		Seychelles		Vietnam	
Cabo Verde		EU and EFTA		Morocco		South Africa		Zimbabwe	
Cambodia		Ghana		Mozambique		St. Lucia			
Canada		India		Nigeria		Thailand			
Chile		Indonesia		Pakistan		Türkiye			



Source: compiled by the authors based on ***Commonwealth of Australia, 2022; Rahman, n.d.; Pereira, 2023; TDA, 2019; IEA, 2022h; Kak, 2022; Government of Canada, 2022a; Government of Chile, 2021; UNFCCC, 2022b; Government of Colombia, 2019; Egyptian State Information Service, 2021; Government of El Salvador, 2020; GFEI, 2020a; ITF, 2022; Government of India, 2019; IEA, 2020a; Government of Japan, n.d.; Kenya Power, 2022; KEA, 2021; Government Government of Malaysia, 2022; Government of Mauritius, 2020; Government of Mexico, n.d.b; Electricidade de Moçambique, 2021; Dioha & Caldeira, 2022; Government of Pakistan, 2019; Government of Paraguay, n.d.; UNEP, 2022b; Government of Seychelles, 2022; Government of South Africa, 2021; TDRI, 2022; Government of Dubai, 2020; CSIL, 2022; Government of Ukraine, n.d.; Government of the United Kingdom, 2022b; The White House, 2021; UNFCCC, 2021e; ICCT, 2022c; UNEPCCC, 2022b;*** *survey responses,* ***OICA, 2023a*** *on vehicle sales and complementary information for countries not individually represented in it.*

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sales) and have vehicle manufacturing with sizeable production capacity. No small vehicle markets are part of this group.

Armenia, Bosnia and Herzegovina, Chile, Colombia, Indonesia, and Pakistan have policies in place for ZEV deployment, while they are developing or considering measures for charging infrastructure. Argentina, Australia, Brazil, Cabo Verde, Cambodia, the Dominican Republic, Egypt, El Salvador, Kenya, Mauritius, Paraguay, Rwanda, Seychelles, South Africa, St. Lucia, Türkiye, Vietnam and Zimbabwe are in the development phase, both for ZEV and charging infrastructure policies. Morocco, the Russian Federation and Ukraine are also developing policies, with a greater focus on vehicles (also for manufacturing) and currently still considering the adoption of specific measures for charging infrastructure. Countries in these groups are nearly entirely LMICs. They have completed the development of a national electromobility strategy or have integrated e-mobility in their NDC and they started to develop implementing measures, but they do not have a regulatory framework to support a ZEV transition. As in the case of fuel economy policies, many of these countries have manufacturing capacity (Argentina, Colombia, Indonesia, Malaysia, Morocco, Pakistan, the Russian Federation, South Africa and Türkiye). Some are vehicle exporters, but none is a major global automotive manufacturer.

Countries with the widest policy development gap on ZEVs and chargers include Azerbaijan, the DRC, Iran, Mozambique, Nigeria, Saudi Arabia, Uganda, and Uzbekistan. The remaining countries that are considering but not yet developing ZEV and charging infrastructure policies, include Bangladesh, Ethiopia, Ghana and Malaysia. Almost all are LMICs (the sole exception is Saudi Arabia), medium or small markets, and generally open to importing second-hand vehicles. Malaysia is the only vehicle manufacturer in this group. Ghana is making progress to move towards their development (**UNEP, 2022a**). Based on feedback received in comments to this analysis, Malaysia is also taking serious action to accelerate policy developments regarding electric mobility.

To reduce the impact of ZEV charging on peak electricity demand, which in most LMICs is set to increase over the next few years, more efficient charging behaviour should be encouraged at off-peak periods. Introducing energy pricing mechanisms reflective of time of day patterns or battery swapping arrangements to spread charging activity over time are other possible solutions (**World Bank, 2022**). Currently, HICs and only very few LMICs have taken action to ensure that price signals can help enhance demand response. Increased reliance on smart charging, allowing to manage charging and even integrate vehicle batteries as energy storage in the electricity grid, are bound to gain importance with increasing shares of renewable electricity (discussed in the following section).

POLICIES FAVOURING A PROGRESSIVE TRANSITION TOWARDS LOW CARBON ELECTRICITY PRODUCTION

Given their greater energy efficiency, ZEVs are less carbon intensive than ICEVs even before the electricity grid is fully decarbonised (**World Bank, 2022**). However, decarbonising the power grid is instrumental in order to maximise the environmental, economic and health-related benefits of electromobility. Further benefits also come from increased pressure, particularly from Europe, to source materials from supply chains with a low-carbon energy (and electricity) mix (**World Bank, 2022**).

Current carbon intensity of electricity production varies greatly in the countries analysed, and, consequently, so does the potential of ZEVs to decarbonise road transport without a transition towards low-carbon electricity production. For example, if electricity was low-carbon, electric mobility could prove to be 90% more beneficial in a country like Poland,[39] which generates electricity primarily from fossil fuels (**World Bank, 2022**). The same could happen in countries such as Egypt or Uzbekistan, where the share of renewable energy in electricity capacity in 2023 is 10.6% and 12.2% respectively (**IRENA, 2022b**).

Figure 14 gives an overview of the policy ambition found in the countries, based on considerations on their current electricity generation mix, the presence of clear objectives to reduce its carbon intensity with renewables and other low-carbon sources of electricity. The pie charts show policy ambitions weighted on the basis of the size of vehicle markets and current carbon intensity of electricity mixes, to suggest where there could be the most relevant criticalities in the presence of growing trade restrictions based on carbon intensity.

Table 3 summarises country-specific targets for electricity generation from renewable energy sources and their timelines (also used for the assessment of Figure 14), adding information (in notes) about the status of nuclear energy (as it is currently the main very low-carbon alternative to renewables) and listing all relevant sources of data and information, for transparency. Figure 15 illustrates the renewable electricity targets to Table 3.
Countries categorised amongst those with an

TABLE 2. OVERVIEW OF ZEV AND CHARGING INFRASTRUCTURE POLICIES

Country	Actions	Sources
Argentina	Argentina proposed a framework legislation on e-mobility, focusing on domestic production of EVs, including a proposal for a ban on the sale of new ICE vehicles from 2041, public procurement of EV fleets and the establishment of a National Agency for Sustainable Mobility.	IEA, 2022g
Armenia	Armenia has tax incentives for the uptake of electric vehicles, notably by eliminating VAT on e-vehicle imports. The IEA also acknowledges programmes to develop a network of EV charging infrastructure, although not tied to the use or expansion of renewable energy in electricity generation.	IEA, 2022d
Australia	Australia developed a National Electric Vehicle Strategy, committed to a target of 75% of new purchased and leased vehicles in the national public fleet to be EVs by 2025 and adopted tax and import tariff arrangements to make EVs more affordable. The Australian Government is developing a National Battery Strategy and a National Reconstruction Fund to drive investment on clean energy component manufacturing (amongst other sectors) and to develop Australia's critical minerals sector, including downstream mineral processing capabilities.	Commonwealth of Australia, 2022
Bangladesh	Bangladesh has targets to transform the majority of the passenger cars, bus, trucks and 3-wheeler auto rickshaws to EV by 2030, tax exemptions for EV manufacturing facilities in the country, road and registration tax waivers for EVs and proposals restricting future EV imports to modes with advanced battery technology.	Rahman, n.d.
Bosnia and Herzegovina	Bosnia and Herzegovina also has sizable fiscal incentives for the purchase of BEVs and PHEVs, but no provisions regarding public investments or support related with charging infrastructure.	Transport Community, 2022
Brazil	Brazil aims to ban the sale of fossil fuel-powered cars by 2060, it is considering both incentives and import tariffs for EVs and it is discussing possibilities to install productive capacity in the country with the Chinese BYD. Some states are already developing charging hubs for trucks, buses and cars. A recent legislative proposal addresses the obligation of having charging points at petrol stations on federal highways, but it is limited to cars.	IEA, 2022h; Trindade, 2022; Goulart, 2023; Reuters, 2023c; Pereira, 2023; Portal Movilidad, 2023b
Cabo Verde	Cabo Verde has set a set of ambitious targets, starting from the achievement of 100% EVs in all vehicle fleets by 2050 (and interim sales targets), despite not being a manufacturer nor a major market. The need for a national charging infrastructure that intelligently manages requests imposed by charges in various types of locations, without any obstacles to interoperability, identification or billing, is also foreseen.	IEA, 2022h
Cambodia	Cambodia has a commitment to reach 70% of electric motorcycles, 40% of both electric cars and urban buses in the country's vehicle fleet by 2050.	Kak, 2022

Country	Actions	Sources
Canada	Canada has ambitious regulations, including an ICEV phase out by 2035, incentives for EV purchase or leasing and budgetary allocations for the support of charging infrastructure, set for approval in 2023 and adding to a legally-binding phase out target for ICEVs, already in place in British Columbia. Furthermore, Canada has proposed regulations requiring manufacturers and importers to ensure that their new light-duty vehicles sales have specific ZEV annual targets. These would begin with model year 2026 and reach full stringency in 2035.	Government of Canada, 2022a; Government of British Columbia, n.d.; Government of Canada, 2023a
Chile	Chile's National Mobility Strategy also foresees a progressive transition, with a 100% electrified fleet of urban public transport, light and medium vehicles by 2030; mining, forestry, construction and agricultural machinery by 2040 and freight transport and intercity buses by 2045. Chile's energy efficiency law gives ZEVs three times the energy efficiency credits of traditional vehicles, which encourages ZEV adoption and helps improve the corporate average. ZEVs, however, are not regulated, not incentivised with fiscal policies. The Ministry of Energy has also been empowered to regulate the interoperability of EV charging systems to facilitate charging network access for more users.	Government of Chile, 2021; ICCT, 2022b
China	China developed one of the most comprehensive global policy frameworks for the roll out of EVs, for two wheelers, light vehicles, heavy vehicles, and charging infrastructure, including regulatory requirements for EV deployment, restrictions to ICEV use in major cities, incentives for vehicle acquisition (currently being considered for a phase out) and industrial development, at the national and State level, resulting in high adoption and a major presence in the EV supply chain.	IEA, 2022h; ICCT, 2021b; UNFCCC, 2022b
Colombia	Colombia developed a National Electric Mobility Strategy. It sets a target of 600,000 electric vehicles by 2030. Policies include financial incentives for the substitution of old vehicles and the electrification of official government vehicles. The Strategy mentions technical standards, financial and normative instruments related with charging infrastructure, identifying taxis and public fleets as possible early adopters.	Government of Colombia, 2019; van Laake, Lozano, & Gillod, 2021
Dominican Republic	The Dominican Republic developed an e-mobility strategy, with an initial focus on public transport, clear references to the relevance of EVs to meet its climate goals and already legislated on electricity tariffs for charging infrastructure.	Presidencia de la República Dominicana, 2023
El Salvador	El Salvador has legislation in place giving economic advantages to EVs (waiving import duties and parking fees) and setting a basis to enable the development of infrastructure.	Government of El Salvador, 2020
Ethiopia	Ethiopia modified taxation on EVs in late 2022 and took early steps to make charging infrastructure available.	EfD, n.d.

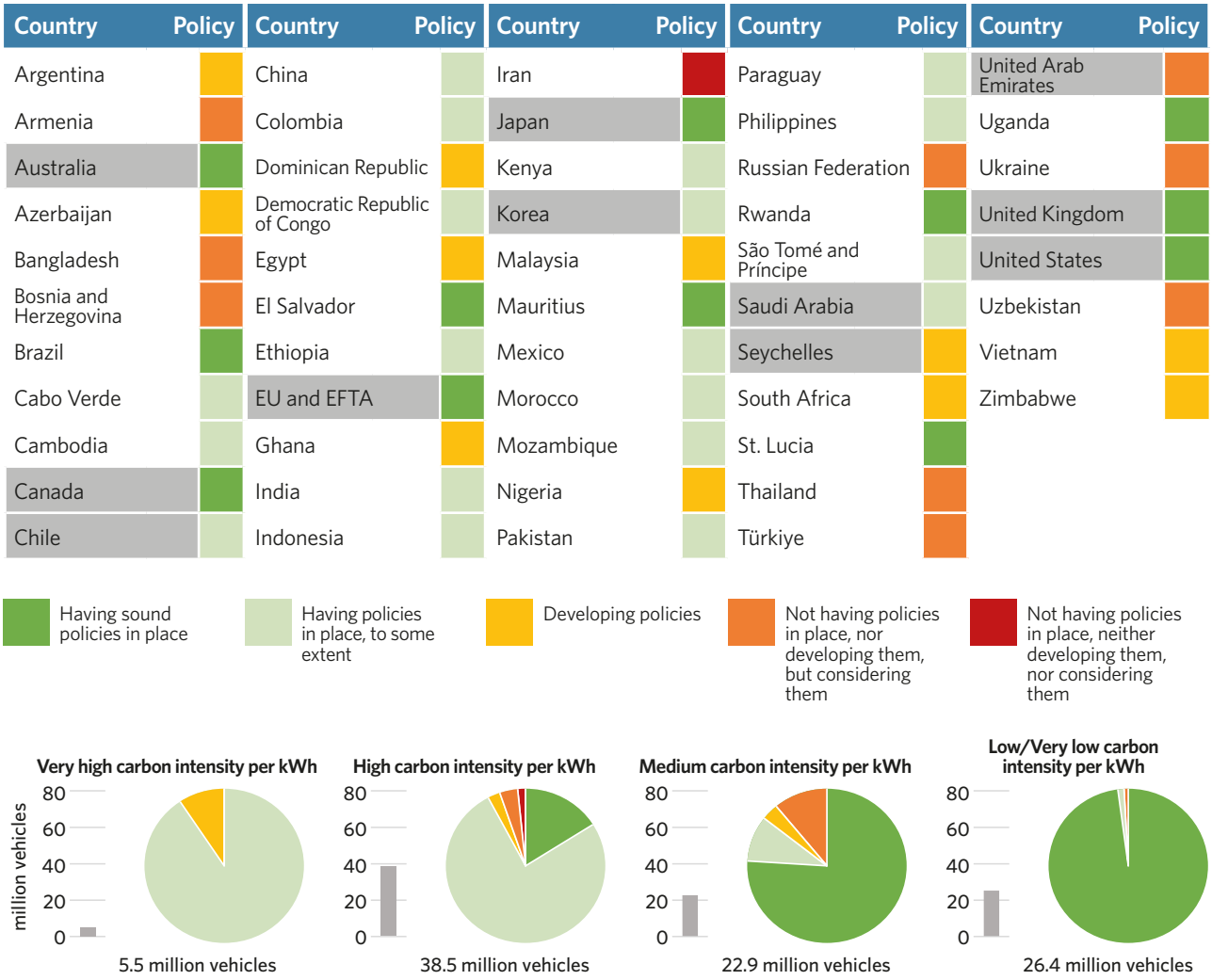
Country	Actions	Sources
EU and EFTA	Currently framed in the European Green Deal, the ZEV policy framework in the EU is amongst the most comprehensive globally. Adding to high fuel taxes, now also integrating carbon pricing, it includes regulatory requirements for EV deployment (in place for light vehicles, with a 2035 phase out for ICEVs, and proposed for heavy vehicles), charging infrastructure (being finalised), restrictions to ICEV use in major cities, country-specific differentiated taxation and incentives for vehicle acquisition and growing opening for the support of industrial development resulting in high EV adoption but not yet sufficient to ensure a major presence in the EV supply chain.	European Commission, n.d.
Ghana	Ghana is in an early phase of EV policy development. A "Drive Electric Initiative" sought to promote and create demand for electric vehicles in 2019/20. The country also worked with UNEP to develop, a National Electric Mobility Policy and Market Readiness Framework, with recommendations on institutional frameworks, technical, fiscal and social measures and the development of a local industry. It recently published its EV Baseline Survey Report.	GFEI, 2020a; UNEPCCC, 2022a; Government of Ghana, 2022
India	India has a comprehensive set of policies meant to support the EV transition. These include an incentive scheme geared towards two-wheelers and buses, budgetary commitments for charging infrastructure (including but not limited to battery swapping) and for the development of EV manufacturing and battery supply capacity. India revised its guidelines and standards for charging infrastructure in 2022. The updated version covers all vehicle types, simplifies the requirements for installing chargers, lowers electricity tariffs and sets a limit to electricity fees charged at public charging stations. India also issued, in 2022 a draft policy to promote battery swapping technology for electric two and three-wheelers.	IEA, 2022b; Government of India, 2022a; Government of India, 2022b
Indonesia	Indonesia developed an industrial policy to support, defend and expand its position in car manufacturing and emerging supply chains. It includes the goals to have EVs counting for 20% of domestic vehicle sales by 2025 and it integrates mechanisms aiming to utilise local nickel deposits for the domestic EV industry. Indonesia recognizes the importance of charging infrastructure, sets enabling technical standards, and sees value in fiscal incentives to promote the deployment of chargers.	ITF, 2022; IEA, 2023b; AHK, 2023
Japan	Japan has a goal to have all new passenger cars electrified by the mid-2030s. It developed subsidies in place for EV acquisition and charging infrastructure. These are framed in the context of a comprehensive and multi-sectoral Green Growth Strategy. Large-scale investment in EV supply chains is also part of the policy strategy of Japan.	IEA, 2022b; IEA, 2021b
Kenya	Kenya is committed to contributing actively to the momentum around e-mobility, it set a goal of having 5% of all newly registered vehicles being EVs by 2025, also thanks to initiatives by start-up targeting the domestic production of electric motorcycles, buses and off-road vehicles. Despite challenges, it could emerge as the EV hub of the greater Horn of Africa.	IEA, 2022e

Country	Actions	Sources
Korea	Korea has a stated 1.13 million passenger BEV by 2025. It introduced tax exemptions to stimulate EV adoption, as well as industrial policies to increase EV supply, by providing liquidity support and loan guarantees for domestic manufacturers, such as Hyundai and Kia. Korea is working on the deployment of 430,000 charging stations in residential apartments, 146,000 charging stations in commercial areas and 12,000 fast chargers along highways by 2025.	IEA, 2022h; Tenggara, Budiarto, Prawira, Prakoso, & Ibrahim, 2021; KEA, 2021
Malaysia	Malaysia developed an industrial policy to support, defend and expand its vehicle manufacturing industry and emerging supply chains. This allows for negotiated incentives for manufacturers and targets different technologies, including EVs but without a clear orientation towards them. Malaysia's EV policies have a limited focus on stimulation of domestic demand and the deployment of infrastructure needed for access to electricity.	ITF, 2022
Mexico	In Mexico, federal and local legislation provides for diverse incentives or supports for the use of EVs. The federal taxation law exempts BEVs (and hybrids) from import or sales fees. The Income Tax Law grants deductions to people purchasing or leasing electric and hybrid vehicles. Investments in public power supply facilities for EVs are also granted a tax credit of 30%. The Comisión Federal de Electricidad (CFE), along with the vehicle industry, is working to improve the recharging infrastructure in the country.	CMS, 2023a
Morocco	Morocco developed an EV roadmap, it has VAT and excise duty reductions in place for EVs and other fuel efficient vehicles. Charging infrastructure is still limited, but part of the roadmap. Moroccan authorities are seeking to attract both electric car and battery manufacturers, with plans by Stellantis to install a gigafactory and EV production capacity.	Ikken, 2022; Mousjid, 2022
Nigeria	Nigeria considers that EVs are realistic after the year 2030, in its Energy Transition Plan.	Government of Nigeria, n.d.
Pakistan	Pakistan's national EV policy includes fiscal incentives for EV acquisition and for investments in the EV value chain, as well as improvements in the governance structure of e-mobility policy. Pakistan's National Electric Vehicles Policy (NEVP) breaks down goals per vehicle type too. It covers cars (30% of new sales by 2030 and 90% by 2040); two and three-wheelers (50% of new sales by 2030 and 90% by 2040); buses (50% of new sales by 2030 and 90% by 2040) and trucks (30% of new sales by 2030 and 90% by 2040).	Government of Pakistan, 2019
Paraguay	Paraguay created a fund for the promotion of electric transport and the gradual transition from ICEVs to EVs, with 10% of revenues from the consumption tax on gasoline and started working on a Master Plan for e-mobility. This is still under development.	Government of Paraguay, n.d.

Country	Actions	Sources
Philippines	The country's Comprehensive Roadmap for the Electric Vehicle Industry (CREVI) is yet to be incorporated in the Philippine Energy Plan and the National Transport Policy. The current policy focus is to support and expand its position in car manufacturing and emerging supply chains. A tariff exemption for EV components is meant to encourage local assembly. Lighter vehicles (two and three-wheelers) are also in greater focus. Framework conditions for charging infrastructure deployment, maintenance and use are set, as well as an inventory of charging stations and service providers. Partnership with the United Nations Industrial Development Organisation (UNIDO) to deploy publicly accessible charging infrastructure in five major cities between 2022 and 2027.	Government of the Philippines, 2022; Crismundo, 2022
Rwanda	Rwanda is working with UNEP to develop e-mobility policies, aiming to have 20% of buses, 30% of motorcycles and 8% of cars electrified by 2030.	UNEP, 2022b
Russian Federation	The Russian Government Increased Investment for Electric Vehicles, with a plan that envisaged significant investments by 2030. The objective is to manufacture 730,000 electric vehicles (EVs) in the 2022-30 period, with an initial production target of 25,000 by the end of 2024. The programme says that sufficient charging infrastructure for EVs is one station for every 10 electric vehicles.	Krasinskaya, 2021
South Africa	The automotive industry is calling for the establishment of an EV policy and issued a green paper to lay the groundwork for a policy formulation. This supplements earlier work by the Government on a Green Paper aiming to establish an EV policy foundation and strategy. South Africa's Just Energy Transition Investment Plan (JET IP) has concrete targets for e-mobility.	Government of South Africa, 2021; NAAMSA, 2023; Government of South Africa, 2023
Türkiye	Currently, Türkiye does not have all-inclusive legislation for EVs, but it does have technical standards, some regulatory requirements (e.g. on minimum parking spaces for parking lots) and tax incentives. The Government of Türkiye also announced an action plan to encourage the use of EVs – including extending the current tax incentives and planned new legislation.	CMS, 2023b
Uganda	Despite important efforts to increase the market penetration of electric two-wheelers in the country, there is limited progress towards market entry of other vehicles, such as private cars, minibus taxis and buses in Uganda. Given the large number of second-hand vehicles imported and the lack of purchasing incentives for EVs, market adoption for EVs is expected to be slow.	Toll, 2023; CSIL, 2022; CIG, 2021
Ukraine	Ukraine introduces draft laws facilitating use of electric vehicles and electric buses, including exemptions from import VAT and customs duty, tax advantages for companies that exclusively manufacture electric engines, batteries, charging equipment and EVs, and requirements for a full transition to EVs of publicly owned vehicles by 2030.	CMS, 2021

Country	Actions	Sources
United Arab Emirates	To promote the use of EVs, Dubai Electricity and Water Authority and Road Transport Authority are working jointly on incentives such as free parking, exemption from toll and reduced registration fees. They aim to make public transport emission-free by 2050. Mubadala Investment Company, Abu Dhabi's strategic investment arm, also signed an agreement with French utility Engie to develop a digital platform to charge EVs in the UAE capital and across the Middle East.	Sharma, 2022
United Kingdom	The UK has one of the most comprehensive policy frameworks globally, combining regulatory requirements for EV deployment (with an ICEV phase out proposal for light vehicles in the final stage), ZEV deployment targets, fiscal support for the installation of chargers, differentiated taxation and incentives for vehicle acquisition and incentives supporting industrial development.	Government of the United Kingdom, n.d.
United States	The ZEV policy framework in the US is amongst the most comprehensive globally, in part thanks to historical leadership from California, and more recently following choices related with industrial policy, enacted at the Federal level. Policies include regulatory requirements for EV deployment (light and heavy vehicles) in California and other States, federal ZEV deployment targets, significant budgetary allocations for the development of charging infrastructure and incentives for vehicle acquisition and incentives meant to support the emergence of a major presence in the EV supply chain.	CARB, n.d.b; Government of the United States of America, 2023
Vietnam	The Vietnamese government approved an Action Programme which aims to achieve net-zero emissions in the transport sector by 2050 and sets specific national objectives related to promoting electric vehicle development, including the promotion of production, assembly, import, and use of EVs and developing charging infrastructure and, by 2040, ending the production, assembly, and import of fossil-fuelled cars, motorcycles, and mopeds for domestic use.	ICCT, 2022c
Zimbabwe	Zimbabwe developed a national policy roadmap for e-mobility with the assistance of UNEP, outlining targets (including a 100% EV uptake for new sales of two and three wheelers by 2035, a 60% share of private cars new sales and a 30% of intra-city buses share of ZEVs by the same date), a wide range of policy tools and pairing then with a timeline, spanning from 2022 to 2030.	UNEPCCC, 2022b

Figure 13. Summary of measures supporting a transition to low-carbon electricity production



Source: compiled by authors, based on ***Government of Argentina, 2019; IEA, 2022d; Parliament of Australia, n.d.; Government of Azerbaijan, n.d.; Government of Bangladesh, 2016; World Energy, 2022; Government of Brazil, 2022; Chaker, 2021; Government of Canada, 2023b; Government of Chile; n.d.; UNFCCC, 2022b; UNCTAD, 2021; UNFCCC, 2020; UNDP, 2021; Government of Egypt, 2021; UNFCCC, 2021b; REN21, n.d.; IEA, 2019b; Government of India, 2022c; Government of Indonesia, 2020; IEA, 2020a; Ohbayashi, 2022; IEA, 2014; IEA, 2020b; Government of Malaysia, 2022; IEA, 2021d; Government of Mexico, 2020; UNFCCC, 2022d; Electricidade de Moçambique, 2021; Nicholas, 2021; Government of Paraguay, 2016; Government of the Philippines, 2023; Climate Transparency, 2021; Se4All, 2016; ALER, 2022b; EMBER, 2022; Government of South Africa, 2022; TDRI, 2022; Cevrioglu, 2023; Bloomberg NEF, n.d.; OECD, 2020; Government of the United Kingdom, 2022c; NPR, 2023; UNFCCC, 2021e, International Trade Administration, 2022e****; survey responses,* ***OICA, 2023a*** *on vehicle sales and complementary information for countries not individually represented in it.*

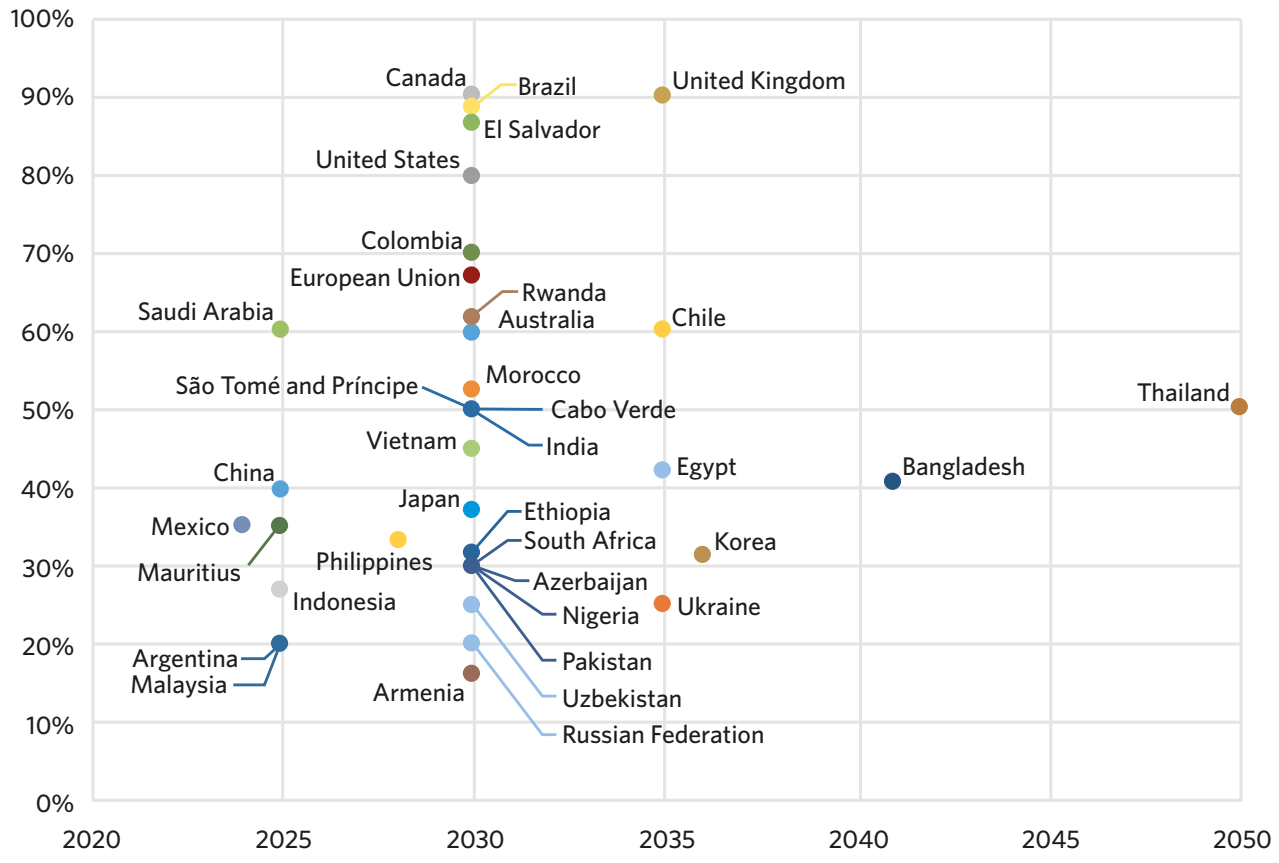
Notes: EU = European Union; EFTA = European Free Trade Association. Major global markets include China, the European Economic Area (plus Switzerland), India, Japan and the United States. Major markets include Australia, Brazil, Canada, Indonesia, Korea, Mexico, Russia, Thailand and the United Kingdom. Medium markets include Argentina, Chile, Colombia, Egypt, Iran, Malaysia, Morocco, Nigeria, Pakistan, Philippines, Saudi Arabia, South Africa, Türkiye, the United Arab Emirates, Ukraine, Uzbekistan and Vietnam. Minor markets include Armenia, Azerbaijan, Bangladesh, Bosnia and Herzegovina, Cabo Verde, Cambodia, Dominican Republic, the Democratic Republic of Congo, El Salvador, Ethiopia, Ghana, Kenya, Mauritius, Mozambique, Paraguay, Rwanda, São Tomé e Principe, Seychelles, St. Lucia, Uganda and Zimbabwe. Grey shading in the table is used for HICs.

ambitious policy framework include Australia, Brazil, Canada, El Salvador, the EU, Japan, Mauritius, Saint Lucia, Rwanda, Uganda, the UK and the US. Reasons for this categorisation lie in ambitious targets (see Table 4 and Figure 15), organic policy frameworks to shift the electricity mix towards renewables (eventually complementing with nuclear - especially relevant in the case of Japan). Brazil starts from very large shares of hydropower (**Our World In Data, 2023**) and some nuclear generation (**WNA, 2022**). It is working to complement this with other forms of renewable electricity to offset potential reductions in hydroelectricity (**IFC, 2022**). Uganda is also almost entirely reliant on hydropower and is planning to add more than 700 MW of generation capacity (**UNFCCC, 2022a**).

The second batch of countries in Figure 14 includes Cabo Verde, Chile, China, Colombia, DRC, Ethiopia, India, Indonesia, Korea, Mexico, Morocco, Mozambique, São Tomé e Príncipe, Saudi Arabia, and Paraguay. Reasons for these choices differ. DRC, Ethiopia, Mozambique and Paraguay start from highly decarbonised grids, based on hydroelectricity. Mozambique is taking steps to increase generation from new renewables (**ALER, 2022a**), but it may also see natural gas taking a growing share of its electricity generation mix (**AfDB, 2022**). Korea requires sizable shares of nuclear energy - included in its strategy - to complement renewables. Pakistan is also in this group, for the same reason (due to the recent installation of a new nuclear plant). Other countries have transformational ambitions for their mix, starting from a low renewable energy share today.

Argentina, Azerbaijan, Egypt, Ghana, Malaysia,

Figure 14. Renewable electricity targets and timelines



Source: based on the information reported in Table 3.

TABLE 3. TARGETS AIMING TO ENSURE A TRANSITION TO LOW-CARBON ELECTRICITY PRODUCTION

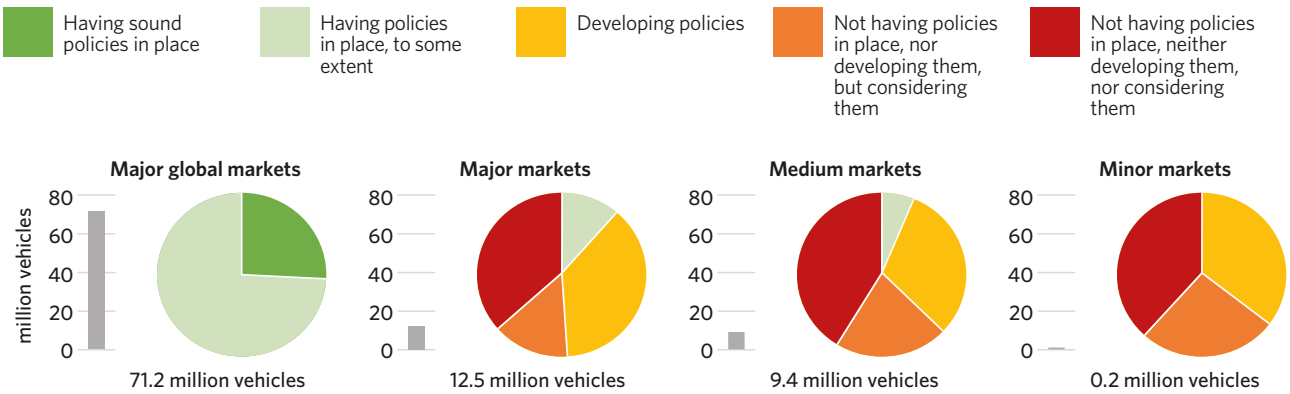
Country	% of renewable electricity production target	Timeline (year)	Sources
Argentina	20%	2025	Government of Argentina, 2015
Armenia	15%	2030	IEA, 2022d
Australia	61%	2030	Commonwealth of Australia, 2021
Azerbaijan	30%	2030	IEA, 2021c
Bangladesh	40	2041	Enerdata, 2023b
Brazil[1]	28-33%, excluding hydro	2030	Bloomberg NEF & CIF, 2021; UNFCCC, 2022c; International Trade Administration, 2023; IFC, 2022
Cabo Verde	50%	2030	UNFCCC, 2021a
Canada[2]	90%	2030	Government of Canada, 2023b
Chile	60%	2035	Government of Chile, n.d.
China[3]	39%	2025	Climate Action Tracker, 2022a; Government of China, 2022
Colombia	70%	2030	US Department of State, 2021
Egypt	42%	2035	International Trade Administration, 2022c; Climate Action Tracker, 2022b
El Salvador	86%	2030	UNFCCC, 2021b
Ethiopia	32%	2030	REN21, n.d.
European Union[4]	65-69%	2030	European Parliament, n.d.; European Commission, 2022a; European Commission, 2022b
Ghana[5]	10%, excluding hydro	2030	IEA, 2019b; International Trade Administration, 2022b; Sarpong, 2023b
India[6]	50%	2030	Government of India, 2022c
Indonesia[7]	26%	2025	Wahyuni & Ardiansyah, 2022; IEA, 2022
Japan[8]	50-60%	2050	Ohbayashi, 2022; Government of Japan, 2021
Korea[9]	30.6%	2036	S&P Global, 2023; Energy Connects, 2023; Enerdata, 2023a
Malaysia	20%	2025	Government of Malaysia, 2022
Mauritius	35%	2025	IEA, 2021d
Mexico	35%	2025	Government of Mexico, n.d.a
Morocco	52%	2030	UNFCCC, 2022d

Country	% of renewable electricity production target	Timeline (year)	Sources
Nigeria	30%	2030	Global Data, 2022a
Pakistan[10]	30%	2030	IAEA, 2022a
Philippines	33%	2028	Government of the Philippines, 2023
Russian Federation[11]	20%	2030	IAEA, 2021b; IEA, 2021e; IFC, 2011
Rwanda	60%	2030	Se4All, 2016
Saint Lucia	60%	2025	Government of Saint Lucia, 2017
São Tomé e Príncipe	50%	2030	ALER, 2022b
South Africa[12]	30%	2030	Climate Action Tracker, 2022c; Global Data, 2022b; Government of South Africa, 2019; Government of South Africa, 2023
Saudi Arabia	50%	2030	International Trade Administration, 2021
Thailand	50%	2050	Enerdata, 2022
Ukraine	25%	2035	OECD, 2020
United Kingdom[13]	90%	2035	Government of the United Kingdom, 2023; Carbon Brief, 2023
United States[14]	80%	2030	The White House, 2021
Uzbekistan	25%	2030	International Trade Administration, 2022d; IEA, 2021i
Vietnam	45%	2030	Climate Action Tracker, 2022d

1 Brazil prices currently roughly 75% of its electricity from hydro (Our World In Data, 2023), and 3% from nuclear (WNA, 2022).
2 Nuclear electricity accounts currently for roughly 15% of the total generated in Canada (Canadian Nuclear Safety Commission, 2022).
3 Nuclear power accounts for 5% of the electricity generation in China (WNA, 2023a).
4 This adds to a share of nuclear electricity close to 25% in 2022 (Eurostat, 2022).
5 Ghana currently produces a third of its energy from hydropower (International Trade Administration, 2022b), down from 70% in 2010 (Our World In Data, 2023).
6 Nuclear power contributed to roughly 3% of electricity generation in India,in 2021-22 (Government of India, 2022c).
7 Estimate based on a target set for 2025 is 23% for new renewables (Wahyuni & Ardiansyah, 2022), adding to hydropower, which accounted for 3% of the production mix in 2021 (IEA, 2022f). Indonesia also has decarbonisation targets for later years, with significant growth in the share of renewables in the primary energy mix.
8 This adds to a 20-22% target from nuclear, in 2030 (Government of Japan, 2021).
9 Sources refer to an updated plan of the Ministry of Trade, Industry and Energy, which includes a 34.6% share of nuclear, amongst low-carbon sources (S&P Global, 2023; Energy Connects, 2023; Enerdata, 2023a).
10 Nuclear power contributed to 11% of Pakistan's electricity mix in 2021 (WNA, 2023b), and 27% in December 2022 (Khan & Malik, 2023).
11 The share of nuclear energy in the Russian Federation was 19% in 2019 (WNA, 2021).
12 Nuclear electricity contributed for 6% of electricity generation in South Africa (IAEA, 2021a).
13 Estimate based on an actual target is a fully decarbonised power system by 2035, including contributions from nuclear and carbon capture and storage, the fact that nuclear contributes to 15% of electricity generation in the United Kingdom, most existing nuclear power stations are set to close by 2030 and arguments that both over- and under-investment in nuclear could result in a more expensive, sub-optimal energy system (Government of the United Kingdom, 2022a).
14 Estimate based on a 100% "carbon pollution-free electricity" by 2030, in (The White House, 2021) details in the same document and analysis in (NPR, 2023). Nuclear power plants have supplied about 20% of total annual U.S. electricity since 1990 (EIA, n.d.).

Figure 15. Summary of policies supporting the sustainable production, use, disposal and recycling of EV batteries

Country	Policy	Country	Policy	Country	Policy	Country	Policy	Country	Policy
Argentina		China		Iran		Paraguay		United Arab Emirates	
Armenia		Colombia		Japan		Philippines		Uganda	
Australia		Dominican Republic		Kenya		Russian Federation		Ukraine	
Azerbaijan		Democratic Republic of Congo		Korea		Rwanda		United Kingdom	
Bangladesh		Egypt		Malaysia		São Tomé and Príncipe		United States	
Bosnia and Herzegovina		El Salvador		Mauritius		Saudi Arabia		Uzbekistan	
Brazil		Ethiopia		Mexico		Seychelles		Vietnam	
Cabo Verde		EU and EFTA		Morocco		South Africa		Zimbabwe	
Cambodia		Ghana		Mozambique		St. Lucia			
Canada		India		Nigeria		Thailand			
Chile		Indonesia		Pakistan		Türkiye			



Source: compiled by authors, based on ***Government of Argentina, 2021; Government of Australia, 2023a; Government of Australia, 2023b; IDS Brasil, 2022; TDA, 2019; IEA, 2021c; Electric Autonomy Canada, 2023; Government of Chile, 2021; ITF, 2021; Government of Colombia, 2017; Climate Action Tracker, 2022b; Government of El Salvador, 2020; UNEPCCC, 2022a; The Gazette of India, 2022; Huber, 2022; Kenya Power, 2022; Government of Malaysia, 2022; Government of Mauritius, 2020; Portal Movilidadm, 2022; Tanchum, 2022; Government of Pakistan, 2019; Government of Paraguay, n.d.; UNEP, 2022b; Government of Seychelles, 2022; Government of South Africa, 2021; TDRI, 2022; EY, 2020; Resmî Gazete, 2020; Bloomberg NEF, n.d.; Government of Ukraine, n.d.; Government of the United Kingdom, 2023; EPA, 2023; US Congress, 2022; CalEPA, 2022; IEA, 2022i; International Trade Administration, 2022e; Aoki, 2022; The Star, 2022; UNEPCCC, 2022b;*** *survey responses and,* ***OICA, 2023a*** *on vehicle sales and complementary information for countries not individually represented in it.*

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Nigeria, Seychelles, South Africa, Vietnam and Zimbabwe are classified in the third category (developing policies), as they have targets in place with a lower ambition (see Table 4 and Figure 15), or have set ambitious targets but are struggling to move towards them. Egypt and Seychelles show early signals of change, but starting from very low renewable shares (**Chandak, 2022; Smith, 2022**). This assessment also takes into account starting points that could allow for further action more (as in the cases of Ghana and Vietnam, due to a sizable contribution from hydroelectricity) and the recent addition of coal generation capacity in Zimbabwe (**Reuters, 2023b**).

Countries qualified as considering but not developing policies include: Armenia, with one of the lowest 2030 targets (see Table 4 and Figure 15); Bangladesh, with a moderate target past 2040; Bosnia, which is heavily reliant on coal and made little progress on policies (**Energy Community, 2022**); the Russian Federation - despite sizable shares of nuclear, due to little ambition on renewables (see Table 4 and Figure 15); Thailand, which has a distant target in terms of timeline (2050) and it starts from a sizeable shares of hydro; Türkiye and the United Arab Emirates - as they have not developed a sectoral target, even if they have announced net-zero economy visions and timelines (like many others above); Ukraine; and Uzbekistan, whose targets are amongst the less ambitious, in terms of renewable energy shares. Iran, still fully reliant on fossil energy, is classified as not having policies in place.

Overall, the pie charts in Figure 14 (where countries are weighted on the basis of the scale of their light duty vehicle market) shows that countries classified as having an ambitious set of objectives to decarbonise electricity and a supportive policy framework are more frequently paired with lower emission intensities for their electricity generation. It also shows that, when looking at results accounting for vehicle market sizes, the majority of EVs are currently used in conditions that have a policy framework in place. Improvements are more urgent in LMICs still distant from attaining lower emission levels and significant growth expected in terms of scale, due to increased motorisation. Based on emission intensity of the electricity grid, classification in terms of policy ambition and market size, the following LMICs are in focus for support in the transition: Iran, Egypt, Malaysia, Thailand (mainly for policy ambition and timelines), South Africa and Uzbekistan. These are complemented by the UAE in HICs.

POLICIES SUPPORTING THE SUSTAINABLE PRODUCTION, USE, DISPOSAL AND RECYCLING OF EV BATTERIES

The increased demand for battery materials of ZEVs, with associated environmental, social and governance (ESG) risks in the supply chain, has raised debates about the sustainability of ZEV transitions. The overall governance of mineral extraction has been questioned (**NRGI, 2021**; **OECD, 2022**; **Tyagi, et al., 2023**), while concerns about how to deal with the end-of-life of various vehicle parts, in particular batteries, are also common worldwide. Although battery recycling technologies are still at an early stage (**ITF, 2021**), these and other proposals could solve what is commonly referred to as the "dead-battery dilemma" (**Morse, 2021**). A policy framework structuring the sustainable production, use, disposal and recycling of EV batteries can help ensure that the entire production cycle of ZEVs is sustainable and ethical, solving part of these problems (**Kendall et al, 2023**).

EV batteries contain raw materials that can be recovered and reused for manufacturing new batteries. After 8-10 years, EV batteries still have around 80% of their usable capacity, which leaves room for generating additional value with their repurposing, typically dedicated to stationary energy storage (**IEA, 2022b**). Recent research suggests that, with about four times lower emissions than virgin materials, recycled materials could reduce the carbon footprint of EVs by between 25-64% (**Nurdiawati & Agrawal, 2022**; **McKinsey, 2023**).[40] Despite this, there are few policies in place aiming to ensure that the raw materials required for batteries are sustainably handled at the end of their useful life. None of them are closing the loop completely to enable a fully circular system, with governance of resource extraction as an outstanding pending issue.

For the transition to ZEVs to be a development opportunity for LMICs and to reduce the sector's consumption levels of virgin resources, policies addressing these two issues are needed before ZEVs reach their end-of-life. Figure 15 summarises the state of policies supporting a sustainable production, use, disposal and recycling of EV batteries. The Figure shows that there is much less awareness of the importance of policy action on batteries than in any other policy reviewed in this study, with only 7 countries having established policies in place (one of which has a full range of instruments aiming to deal with ESG challenges), and 11 countries that are currently developing them. Table 4 summarises current policy frameworks and related sources.

The EU, shown in dark green in Figure 15, is the only case with a comprehensive policy framework in place, covering extended producer responsibility, traceability of battery materials, carbon-intensity, recycling requirements, facilitation tools, and supply chain sustainability and transparency requirements (due diligence). Countries categorised in light green have policies that cover extended producer responsibility, reuse and recycling, clearly going beyond minimum waste management requirements related with safety and handling of hazardous materials. Those ranked in yellow have laws, plans and roadmaps that deal with battery end-of-life management, mostly focusing on safety and hazardous material handling requirements, but falling short in many other aspects of the supply chain. Those listed in orange do not have plans, roadmaps or policies yet, but these are being considered. In most of the remaining countries (Egypt, Cambodia, Armenia, DRC, Iran, Seychelles, Nigeria, Brazil, Russia, Rwanda, Uzbekistan, United Kingdom, etc.), information on the status of EV policies does not include information on sustainable mineral sourcing or battery recycling.

In addition to the overview included in Table 4, the case of DRC has become iconic regarding the sustainability of cobalt mining, underpinning policies requiring due diligence on mineral sourcing practices, to increase transparency and help addressing the complex issue of mining practices, as pointed out by the OECD (see in particular **OECD, 2019a**).

Indonesia, also not included in Table 4, aims to capitalise on its nickel ore reserves (**IEA, 2022b**), and is focusing on industrial capacity development without including sustainability of batteries in its priorities (**Huber, 2022**). Nevertheless, the government will have to further address challenges to conducting business in Indonesia as well as ESG concerns related to nickel mining and processing, to attract investments from battery producers in HICs (**Huber, 2022**).

The message arising from Figure 15 is striking, as it shows a major gap in policymaking, especially in medium to minor markets, but also - on the topic of sustainable sourcing of minerals - in most major markets. Policies and regulations to ensure that the framework in which ZEV policies are developed do not replicate unsustainable business models are decisive, especially in countries where mineral extraction and battery manufacturing has started or is set to start soon. Waste management could cover a considerable part of upcoming material demand, which would be urgently needed in LMICs, given their reliance on second-hand vehicles.

Most battery recycling companies have so far been independent recyclers, but other stakeholders (namely Original Equipment Manufacturers - OEMs-, battery manufacturers, miners and processors) are starting to enter the market (**IEA, 2022b**). Facilitating partnerships among OEMs, actors in the battery supply chain, re-use and recycling companies requires policy frameworks that hold stakeholders responsible for the way they source their batteries and the materials needed for them, enable tracking the carbon intensity and give greater value to products with low embodied carbon, and ensure also that stakeholders are responsible for battery recycling.

Breaking the linearity of vehicle supply chains will be essential to ensure that the transition towards EVs is in line with sustainability requirements. Downscaling of new material use and maximising battery material adoption in applications with high intensity/frequency of use can be an essential part of the solution, along with business models that promote stewardship of products and ensure high resource efficiency per service delivered.

TABLE 4. ACTIONS IN COUNTRIES WITH BATTERY MANAGEMENT POLICIES IN PLACE, BEING DEVELOPED OR BEING CONSIDERED

Country	Actions	Sources
Argentina	A draft law foresees the management of the procedures required to instruct responsible parties regarding the treatment, collection and recycling of used batteries.	Government of Argentina, 2021
Australia	Its first National Battery Strategy is currently being developed and it includes the development of industries to produce batteries nationally. An issue papers related with this Strategy flags that, while Australia has a Battery Stewardship Scheme in place for small consumer batteries, mobile and stationary storage batteries currently do not have similar schemes. Additionally, recycling rates for lithium-ion batteries are currently under 10 per cent, compared to 95 per cent for lead-acid batteries.	Government of Australia, 2023a; Government of Australia, 2023b
Bangladesh	EV policy includes references to incentives to the set up of a battery recycling industry, but this is still at a very early phase of consideration.	Rahman, n.d.
Bosnia and Herzegovina	Currently developing adequate management systems for the disposal of EVs, aiming to apply the producer's extended responsibility principle.	World Bank, forthcoming
Cabo Verde	The vehicle importer is responsible for managing its end-of-life. This covers vehicles in general and specifically EVs, and battery management thereof. Recycling should be done domestically by an accredited company or outside Cabo Verde by a certified company that can guarantee transportation safety. The vehicle importer shall be responsible for battery recycling. In the case of transfer, the collection company should ensure the recycling of the battery at the end of the second life.	TDA, 2019
Canada	Its ZEV policy is yet to be released, but Canada's 2030 Emissions Reduction Plan outlines current plans in Ontario and Québec to develop a national battery industry. Several Provinces have also developed regulatory requirements regarding extended producer responsibility batteries, but a federal policy is not currently in place. However, Canada is considering the introduction of a "passport" for EV batteries in bid for environmental, social and governance standards to the industry.	Government of Canada, 2022b; Invest in Canada, 2022; Electric Autonomy Canada, 2023; Call2Recycle, n.d.; Balakrishan, 2022
Chile	Chile's Law on extended producer responsibility foresees, since 2016, promotes processes associated with battery recycling or final disposal. The country is planning to promote local battery development, and has potential to leverage its lithium reserves. The current legal framework in Chile, and its Electromobility strategy, are silent on due diligence rules regarding mineral sourcing.	IEA, 2022j; Government of Chile, 2021
China	With 77% of the world's battery manufacturing capacity, the country expects that about 3 million used EV battery packs will be available annually by 2029. The country's current capacity for battery recycling is around 100 kt/year, which is half of the world's capacity. China's first regulation on battery recycling, published in 2018, requires OEMs to set up a national network of service stations where car owners can discard or exchange old batteries. It also obligates battery makers to standardise their products to facilitate battery end-of-life management.	Bruno Venditti, 2022; World Bank, 2022; IEA, 2022b; Popova, 2022

Country	Actions	Sources
Dominican Republic	Ensuring the correct recycling of batteries and the management of other hazardous waste is part of the country's National Electromobility Plan.	Government of the Dominican Republic, 2022
El Salvador	El Salvador's Law on the Promotion of Incentives for the Importation and Use of Electric and Hybrid Means of Transport aims to regulate EV batteries' end-of-life and other hazardous waste stemming from EVs. The country's regulation stipulates the management of the correct final disposal of the EV batteries that must be discarded due to their use, as well as other hazardous components or waste that may generate environmental risks.	Government of El Salvador, 2020
European Union	The EU Battery regulation is at the final stages before approval and addresses battery safety, durability, and repurposing, as well as the sustainability of battery supply chains. Importantly, the EU policy includes due diligence rules to ensure transparency on the way raw materials used for batteries are sourced. Europe is also addressing the carbon footprint of some of the battery materials in the framework of its Carbon Border Adjustment mechanism, primarily meant to induce countries that are involved in trade with the European Union to develop carbon pricing mechanisms (and enabling the Union to apply corresponding duties in case these are not in place).	European Council, 2022a; ITF, 2021; Popoa, 2022; European Council, 2022b
Ghana	National Electric Mobility Roadmap acknowledges that management of battery disposal is one of the barriers for EV uptake.	UNEPCCC, 2022a
India	India issued its Battery Waste Management Rules in 2022. They set out obligations of all actors (producers, dealers, consumers) involved in the collection, segregation, transportation, refurbishment and recycling of waste batteries.	The Gazette of India, 2022
Japan	Since the early 2000s, Japan has been a global leader in the 3Rs (Reduce, Reuse, Recycle) and has achieved steady results in reducing the final disposal of waste and improving the recycling rates. It has the ambition of achieving carbon-neutral manufacturing, including production, use and disposal of cars, by 2050.	Popova, 2022; ITF, 2021
Korea	Korea has updated its regulations to allow for environmentally friendly ways to utilise used EV batteries. Extended Producer Responsibility mandates are also in place.	Popova, 2022; KECO, n.d.
Malaysia	Its National Energy Policy Plan 2022-2040 establishes battery regulations to support ZEV adoption.	Government of Malaysia, 2022
Mauritius	Its National Battery Plan foresees requiring EV car importers to guarantee batteries for a minimum of 8 years or 150,000 km for new vehicles. It also foresees that EV importers will be responsible for 2nd life use or recycling of batteries at their end-of-life.	Government of Mauritius, 2020
Mexico	Expected to be among the top 10 Battery Cell Manufacturers by 2027, is developing its Electric Mobility Strategy. This considers the final disposal of batteries, as well as the regulation of their second-life use.	Bhutada, 2023; Portal Movilidad, 2022
Morocco	In partnership with two companies to produce cobalt from recycled battery materials, and being well positioned as a possible battery and EV manufacturing hub, with strong ties to the EU, may have interest to develop a framework for sustainable sourcing of minerals.	Glencore, 2022; Tanchum, 2022

Country	Actions	Sources
Pakistan	Currently exploring how to deal with potential manufacturing capacity of lithium-ion battery packs, which so far are imported.	LUMS, 2021
Paraguay	Paraguay's law on the promotion of e-mobility states that "hazardous waste generated by electric vehicles shall be managed in a special way (...), particularly discarded electric batteries", but does not contain any provision on carbon intensity, nor on due diligence rules to ensure transparency on the way raw materials used for batteries are sourced.	Gaceta Oficial, 2022
South Africa	Government's considerations on the second life of EV batteries do not cover anything on sustainability. Regarding sustainable sourcing, the South African automotive industry association is calling for greater local content flexibility, with the aim to pair developments with the European/UK policy environment.	Government of South Africa, 2021; NAAMSA, 2023
Thailand	Despite having one of the largest automotive production centres in ASEAN, there is still no explicit policy on how to deal with obsolete vehicles and management of batteries at their end-of-life, although they are being considered	IEA, 2022b; TDRI, 2022
Türkiye	The country has a Recycling Contribution Fee in place since 2020. It requires suppliers, importers and stores of a number of products (including car batteries) to pay a fee for their "non-returnable products". If these goods are later returned, the fee can be deducted.	EY, 2020; Resmî Gazete, 2020
United Kingdom	The country is about to open a consultation to review the current Batteries Regulations in the second half of 2023. It will contemplate promoting the recovery, reuse, or recycling of all battery chemistry types.	Government of the United Kingdom, 2023
United States	The US's Bipartisan Infrastructure Law earmarks funds to transform recycling and waste management across various sectors, including EV batteries. Moreover, the country's EV Management Act aims to promote EV battery management of government fleets. The state of California is the most advanced in this space, having created an advisory group to establish practices for 100% reuse or recycling of EV batteries.	EPA, 2023; US Congress, 2022; CalEPA, 2022
Vietnam	Battery manufacturing capacity is being built, but further progress is needed to incorporate sustainability practices into the process. Under the Law on Environment 2020, covering extended producer responsibility, recycling will be mandatory for those producers or importers of batteries, tyres, lubricants and packaging as of 2024, electronics as of 2025, and vehicles from 2027.	International Trade Administration, 2022e; Aoki, 2022; The Star, 2022
Zimbabwe	The National Policy Roadmap for Electric Mobility includes guidelines on how to deal with battery reuse and recycling. However, the policy development process meant to implement this roadmap is still in its infancy.	UNEPCCC, 2022b

KEY FEATURES OF ZEV POLICY ACTION AND ANALYSIS OF REMAINING GAPS

This section combines the clustering exercise outlined in Chapter 3 with the review developed in Chapter 4. It aims to identify cases where policies are lacking, even if it would be important to have them in place. The section also highlights situations where similar framing conditions can help catalyse opportunities for better collaboration between country groups.

The rationale used here builds on the idea that pairing countries in similar framing conditions but at different stages of the ZEV transition can increase chances to seize win-win opportunities to achieve progress in policymaking, with constructive outcomes, ultimately accelerating the global transition.

Table 5 provides a summary review of policies regarding fuel economy improvements, ZEV deployment, ZEV infrastructure (primarily EV charging), battery manufacturing, supply chain sustainability and end-of-life management.

The picture emerging from this table is the result of the overlay of three aspects:

- Vehicle manufacturing countries have been more proactive than non-manufacturers in taking legislative action on all these topics.
- Countries that are net importers of oil and petroleum products are more likely to have policies on energy efficiency (fuel economy) and the ZEV transition (ZEV deployment and related infrastructure, in particular charging for EVs) than oil exporters or countries that are self-sufficient regarding their oil and petroleum product supply.
- HICs are generally ahead of LMICs in the development of environmental legislation, across the board.

In line with activities already developed in international cooperation frameworks (and in particular regional replication activities), it is acknowledged that additional groupings are feasible. For example, taking into account geography, trade-related aspects (e.g. parties of the same free-trade agreements) and on the basis of linguistic criteria (e.g. leveraging the common language across geographies). These will not be the focus of the assessment developed here.

FUEL ECONOMY

Policy developments on fuel economy took place to a greater extent on legacy technologies (ICE vehicles), especially amongst vehicle manufacturers, and also in high-income net oil/product exporting countries.[41]

Notwithstanding this, several LMICs, especially amongst non-vehicle manufacturers, are still lagging behind on fuel economy policies, along with other LMICs that are net oil and petroleum product exporters.

Figure 16 shows that **the countries with the strongest need to make progress on fuel economy policies are LMICs that do not produce vehicles, especially if they are also net exporters of oil and petroleum products. In terms of market size, LMICs with vehicle manufacturing capacity, net exports of oil and petroleum products and no fuel economy policies in place are the most relevant.**

Addressing the gap between HICs and the subset of LMICs that have not taken action on fuel economy improvements can be effectively benefiting from the establishment of bilateral or multilateral frameworks of cooperation. **Bringing together LMICs that are in the same clusters, with respect to vehicle manufacturing and oil/petroleum product trade, of HICs and other LMICs that have already taken policy action, is an option with good chances to accelerate progress**, as it would help addressing questions that may have been answered in countries that have already taken action.

Figure 17 gives an example of possible pairs of countries (or country groups) falling in the same cluster, bringing together economies that have already developed articulated fuel economy policies and others that are not yet at the same stage.[42] Additional opportunities may arise also across the vertical and horizontal dimensions of the figures, i.e. bringing together clusters based on their vehicle manufacturing or oil and petroleum product trade profiles, in isolation. Pairings across the diagonals in the figure are likely most challenging.

ZEV TRANSITION: VEHICLE DEPLOYMENT AND CHARGING INFRASTRUCTURE

While there are similarities between country groups that have taken or are starting to take action on fuel economy and ZEVs, comparing the indications arising from Table 5, Figures 10, 11, 12, 16 and 17, suggests that **ZEV policies can offer opportunities to leapfrog some of the policy development stages typically characterising fuel economy policy**. The presence of higher shares of countries that started developing ZEV and charging infrastructure policies (in comparison with policies targeting fuel economy improvements) among net oil and petroleum product importers without a vehicle manufacturing industry is probably the most striking example of this.

TABLE 5. SUMMARY OF FUEL ECONOMY, ZEV AND BATTERY-RELATED POLICIES, CLUSTERING COUNTRIES BASED ON VEHICLE MANUFACTURING AND NET IMPORTS OF OIL AND OIL PRODUCTS

			Fuel economy improvement policies	ZEV deployment policies	ZEV infrastructure deployment policies	Battery manufacturing, supply chain sustainability and end-of-life policies*
Vehicle manufacturers	HICs	Oil/product importers	Australia, EU and EFTA, Japan, Korea, United Kingdom	Australia, EU and EFTA, Japan, Korea, United Kingdom	Australia, EU and EFTA, Japan, Korea, United Kingdom	Australia, EU and EFTA, Japan, Korea, United Kingdom
		Oil/product exporters or self-sufficient	Canada, United States	Canada, United States	Canada, United States	Canada, United States
	LMICs	Oil/product importers	China, India, Indonesia, Morocco, Pakistan, Philippines, South Africa, Thailand, Türkiye, Ukraine, Vietnam	China, India, Indonesia, Morocco, Pakistan, Philippines, South Africa, Thailand, Türkiye, Ukraine, Vietnam	China, India, Indonesia, Morocco, Pakistan, Philippines, South Africa, Thailand, Türkiye, Ukraine, Vietnam	China, India, Indonesia, Morocco, Pakistan, Philippines, South Africa, Thailand, Türkiye, Ukraine, Vietnam
		Oil/product exporters or self-sufficient	Argentina, Azerbaijan, Brazil, Colombia, Egypt, Iran, Malaysia, Mexico, Russian Federation, Uzbekistan	Argentina, Azerbaijan, Brazil, Colombia, Egypt, Iran, Malaysia, Mexico, Russian Federation, Uzbekistan	Argentina, Azerbaijan, Brazil, Colombia, Egypt, Iran, Malaysia, Mexico, Russian Federation, Uzbekistan	Argentina, Azerbaijan, Brazil, Colombia, Egypt, Iran, Malaysia, Mexico, Russian Federation, Uzbekistan
Non vehicle manufacturers	HICs	Oil/product importers	Chile, Seychelles	Chile, Seychelles	Chile, Seychelles	Chile, Seychelles
		Oil/product exporters or self-sufficient	Saudi Arabia, United Arab Emirates	Saudi Arabia, United Arab Emirates	Saudi Arabia, United Arab Emirates	Saudi Arabia, United Arab Emirates
	LMICs	Oil/product importers	Armenia, Bosnia and Herzegovina, Cabo Verde, Cambodia, Dominican Republic, El Salvador, Ethiopia, Kenya, Mauritius, Mozambique, Paraguay, Rwanda, São Tomé and Príncipe, St. Lucia, Uganda, Zimbabwe	Armenia, Bosnia and Herzegovina, Cabo Verde, Cambodia, Dominican Republic, El Salvador, Ethiopia, Kenya, Mauritius, Mozambique, Paraguay, Rwanda, São Tomé and Príncipe, St. Lucia, Uganda, Zimbabwe	Armenia, Bosnia and Herzegovina, Cabo Verde, Cambodia, Dominican Republic, El Salvador, Ethiopia, Kenya, Mauritius, Mozambique, Paraguay, Rwanda, São Tomé and Príncipe, St. Lucia, Uganda, Zimbabwe	Armenia, Bosnia and Herzegovina, Cabo Verde, Cambodia, Dominican Republic, El Salvador, Ethiopia, Kenya, Mauritius, Mozambique, Paraguay, Rwanda, São Tomé and Príncipe, St. Lucia, Uganda, Zimbabwe
		Oil/product exporters or self-sufficient	Bangladesh, Democratic Republic of Congo, Ghana, Nigeria	Bangladesh, Democratic Republic of Congo, Ghana, Nigeria	Bangladesh, Democratic Republic of Congo, Ghana, Nigeria	Bangladesh, Democratic Republic of Congo, Ghana, Nigeria

**** Countries/economies with a role in the battery supply chain (or plans to have one) are in bold.***

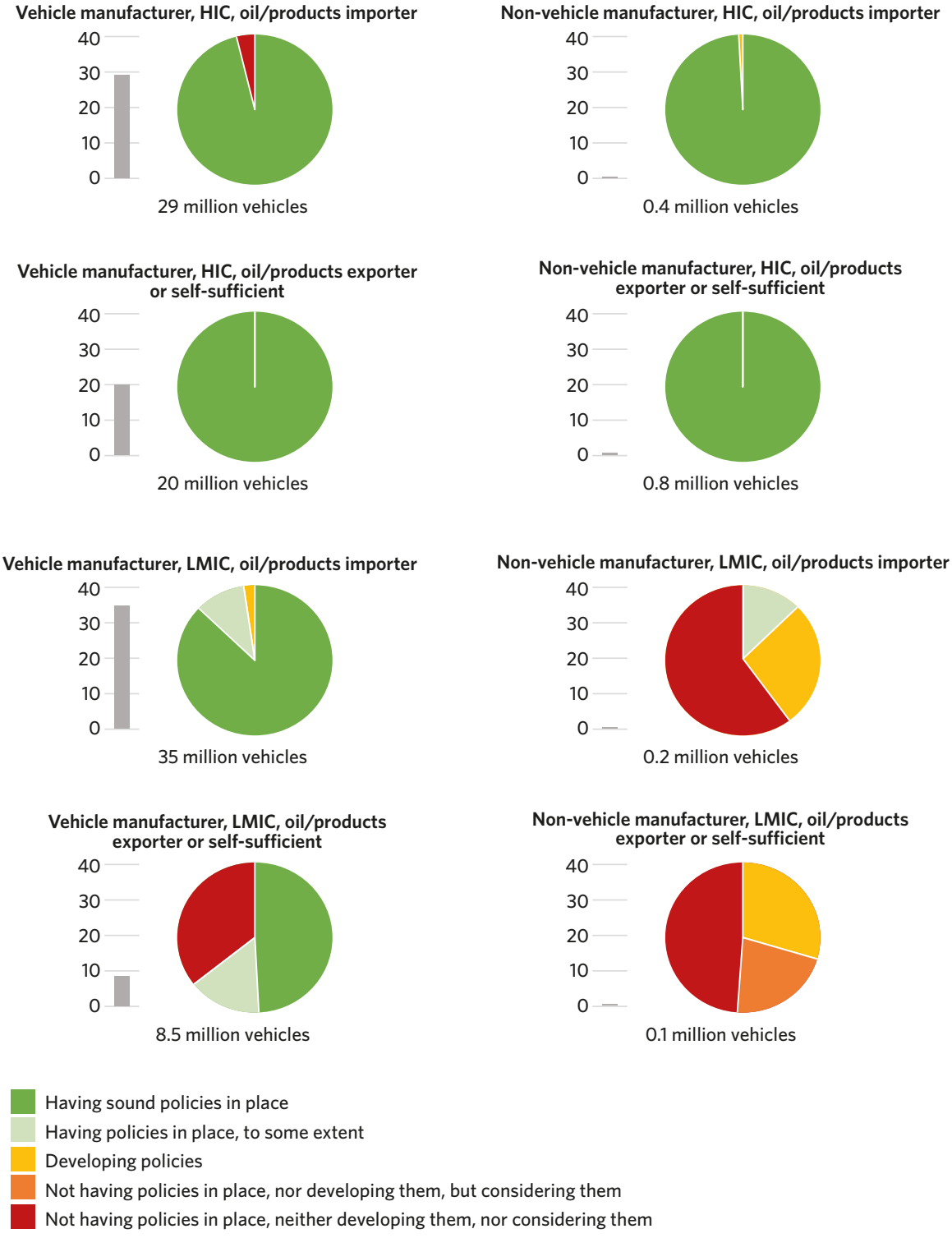
Legend:

Green	Having sound policies in place
Light Green	Having policies in place, to some extent
Yellow	Developing policies
Orange	Not having policies in place, nor developing them, but considering
Red	Not having policies in place, nor considering them

Source: compiled by the authors, based on the sources already cited in earlier Figures and Tables.

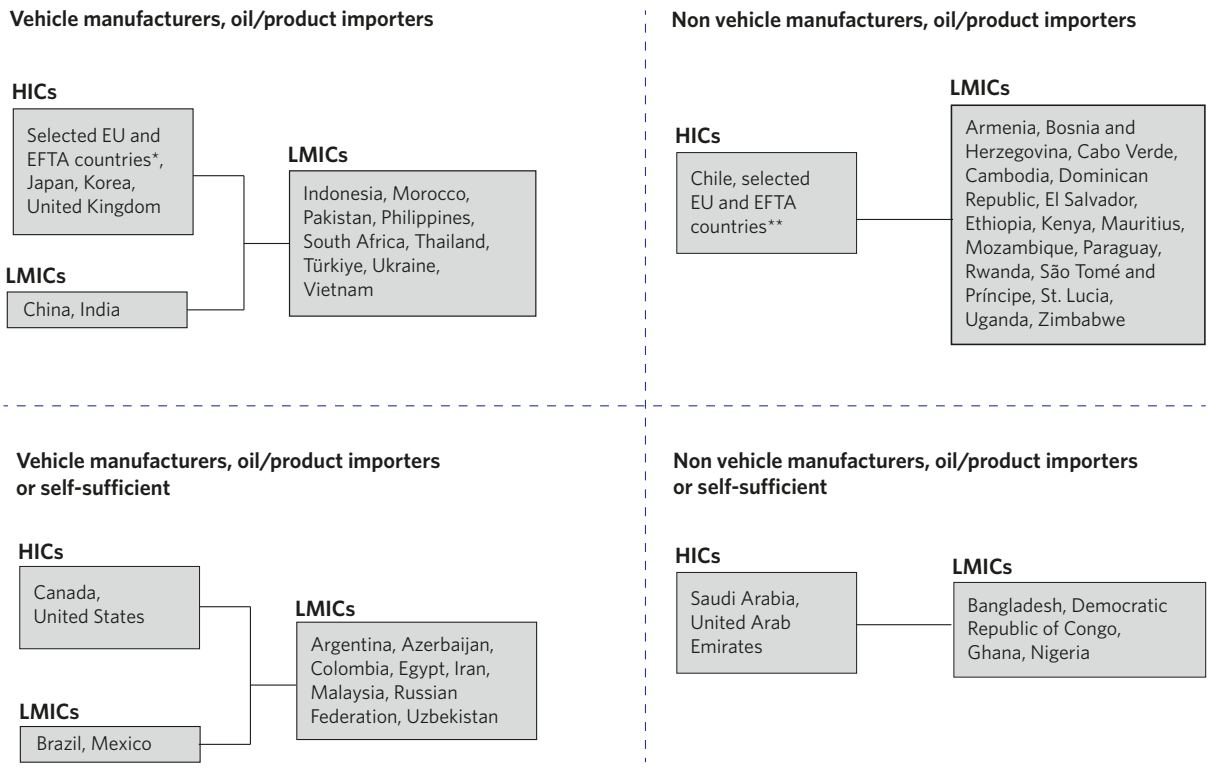
Notes: HICs = high income countries; LMICs: low and middle income countries; EU = European Union; EFTA = European Free Trade Association.

FIGURE 16. SALES-WEIGHTED RESULTS ON FUEL ECONOMY POLICIES, WITH COUNTRIES CLUSTERED BASED ON VEHICLE MANUFACTURING, NET IMPORTS OF OIL/OIL PRODUCTS AND PER CAPITA INCOME



*Source: own assessment by the authors, based on information from Figure 10, data from **OICA, 2023a** on vehicle sales and complementary information for countries not individually represented in the OICA database, IEA energy balance tables, accounting for net trade of oil and petroleum products, combined **IEA, 2022c** and the World Bank's current classification based on countries' GNI per capita (**World Bank, 2023**).*

FIGURE 17. EXAMPLE OF PAIRING BETWEEN COUNTRIES THAT HAVE ALREADY TAKEN AMBITIOUS POLICY ACTION AND OTHERS NOT YET AT THE SAME STAGE, WITH A FOCUS ON FUEL ECONOMY



* Including Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, the Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden.

** Including Bulgaria, Croatia, Denmark, Estonia, Greece, Iceland, Latvia, Lithuania, Luxembourg, Norway.

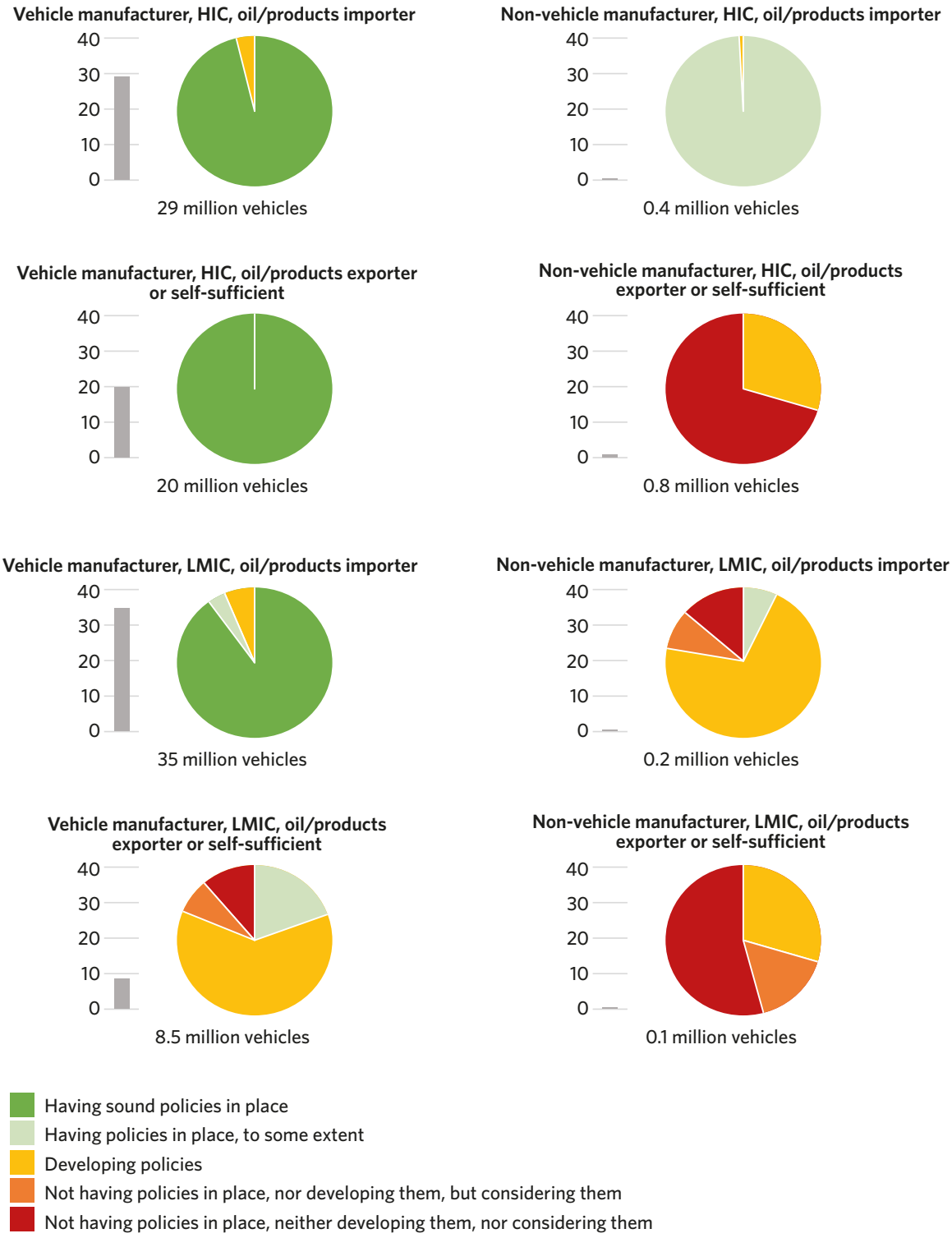
Source: own assessment by the authors.

Evidence that leapfrogging opportunities exist is provided by more proactive developments in the ZEV policy framework of selected countries, if compared with fuel economy improvements. Examples available from observed developments to date include:

- **SIDS** like Cabo Verde and Mauritius, given that the travel distances they require are fully compatible with EVs with a high cost competitiveness profile, due to limited requirements in terms of battery size.
- **Countries that have automotive manufacturing facilities** and have already spotted a development opportunity from a shift to EVs (e.g. because they have natural resources valuable in the supply chain), or have a desire to prevent a loss of competitiveness. Thailand is probably the most relevant example.
- **Countries that are net importers of oil and petroleum products** and see ZEVs as an opportunity to reduce their exposure to oil price volatility and other energy security risks, especially if their electricity generation is largely based on renewable energy. El Salvador and Paraguay are in this category.

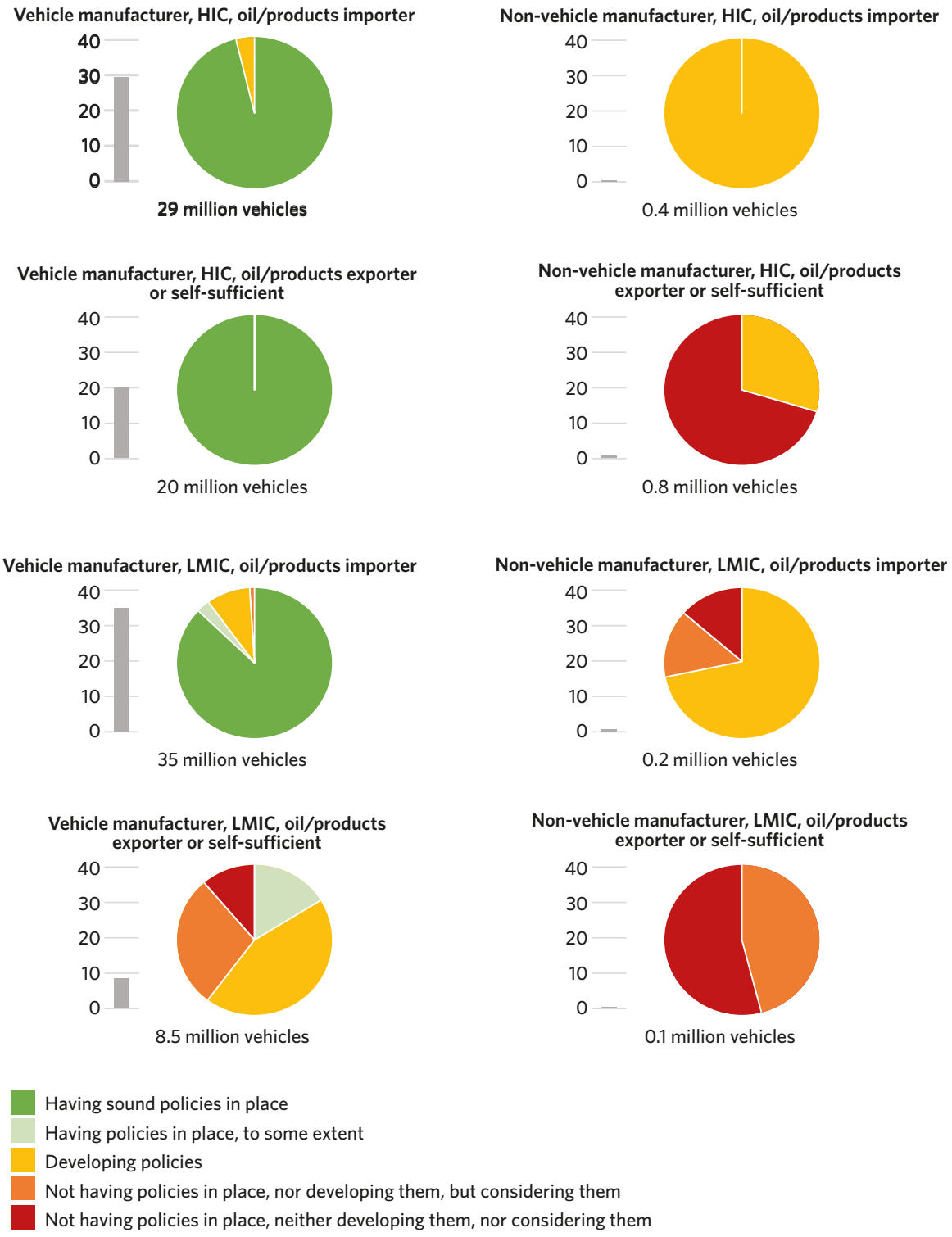
Reasons for a higher likelihood of faster ZEV policy deployment in non-manufacturing countries may also inclu or de the necessity of articulated tools to enable the measurement and reporting of energy use and CO_2 emissions/km. These require specific technical knowledge (paired with automotive industry professional profiles) and are key prerequisites for measures like labelling (to enable consumers to be aware of these performances), the establishment of a national or regional benchmark and the development of differentiated taxation on vehicle registration and/or circulation, based on environmental performances.

FIGURE 18. SALES-WEIGHTED RESULTS ON ZEV POLICIES, WITH COUNTRIES CLUSTERED BASED ON VEHICLE MANUFACTURING PROFILE, NET IMPORTS OF OIL/OIL PRODUCTS AND PER CAPITA INCOME



*Source: own assessment by the authors, based on information from Figure 11, data from **OICA, 2023a** on vehicle sales and complementary information for countries not individually represented in the OICA database, IEA energy balance tables, accounting for net trade of oil and petroleum products, combined **IEA, 2022c** and the World Bank's current classification based on countries' GNI per capita (**World Bank, 2023**).*

FIGURE 19. SALES-WEIGHTED RESULTS ON ZEV INFRASTRUCTURE POLICIES, WITH COUNTRIES CLUSTERED BASED ON VEHICLE MANUFACTURING PROFILE, NET IMPORTS OF OIL/OIL PRODUCTS AND PER CAPITA INCOME



*Source: own assessment by the authors, based on information from Figure 11, data from **OICA, 2023a** on vehicle sales and complementary information for countries not individually represented in the OICA database, IEA energy balance tables, accounting for net trade of oil and petroleum products, combined **IEA, 2022c** and the World Bank's current classification based on countries' GNI per capita (**World Bank, 2023**).*

Box 3. Leapfrogging opportunities from an early transition of highly-utilised vehicles

Highly-utilised vehicles are subject to travel conditions offering significant benefits to reduce emissions and fossil energy demand, especially if used in urban environments. They are amongst the most compelling cases for an early technology switch, from an environmental, energy security and cost-related perspective. Due to their intensive daily travel profile (and the relevance of the transition also for heavy vehicles, like buses), they offer major opportunities to save substantial amounts of fossil fuels, quicker than in a case where the transition was more focused on vehicles whose travel profile is less intensive.

Key examples include buses,[46] three-wheelers (e.g. auto rickshaws in Asia), some two-wheelers (e.g. boda-boda in Africa), some cars (e.g. taxis and vehicles used for ride sharing services), as well as urban delivery vehicles carrying freight (such as light commercial vehicles).

As the cost-competitive transition of these vehicles is compelling with a range of fuel prices (except for cases where the cost of acquisition and borrowing is extremely high),[47] all countries, including LMICs, have interest in developing policies that foster an early transition. Facilitating this shift, both HICs and LMICs have the possibility to seize additional benefits from an industrial development perspective (either as an export or as a development opportunity, depending on the circumstances). With an early transition of their fleet vehicles, LMICs also have the possibility to increase the ZEV availability at lower costs, once they shift towards their domestic used vehicle market.

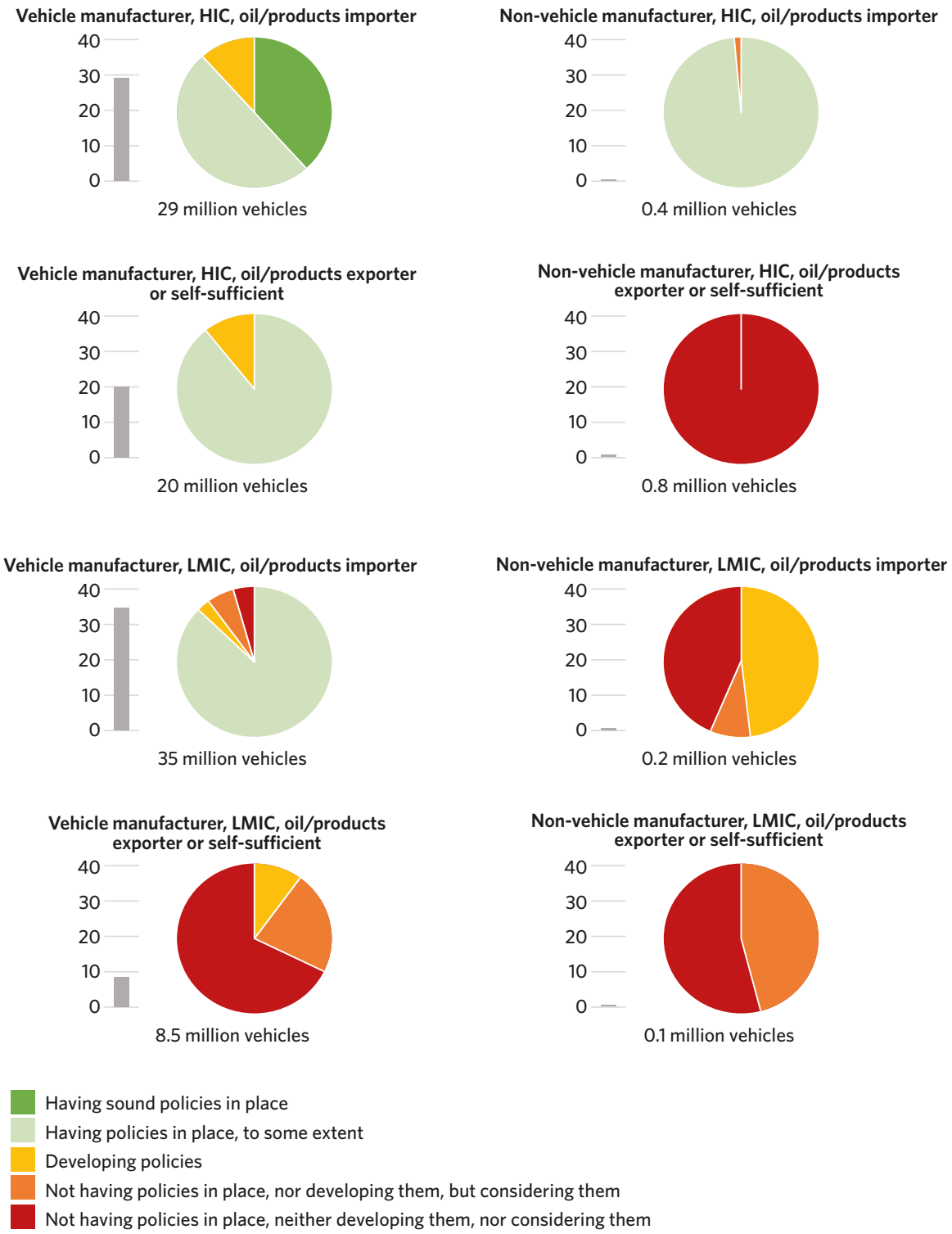
Matching countries or global regions in pairs that respond to this need would require a focus on specific policy tools, targeting the transition of fleets. Examples of these exist in both HICs and LMICs. For HICs, this is the case of policies like the Clean Miles Standard and the Innovative Clean Transit measure, focused on buses (both developed in California), the Clean Vehicles Directive (which requires a switch towards greater ZEV bus shares) and a recent proposal of a CO_2 regulation for heavy vehicles (integrating high requirements for buses) in the EU. For LMICs, key examples include fiscal policies promoting the shift of three-wheelers towards ZEV in India and financial incentives and regulatory requirements for the transition of buses in China.

Countries that are most distant from leapfrogging opportunities are net oil/petroleum product exporters or self-sufficient producers. Reasons lie in lower pressures on the need to manage their trade balance. Figures 18 and 19 flag the criticality of ZEV policy action for countries that are not oil/petroleum product importers. Comparing it with Figure 16 shows that there may be greater chances of a proactive interest from governments in these specific circumstances if the policy focus is more broadly concentrated on fuel economy improvements.

Overcoming this specific challenge is especially important and likely to require dedicated activities. As already pointed out in Table 1, a crucial argument to leverage interest in anticipating the ZEV transition for oil/petroleum product exporters is the relevance that the changes taking place at the global scale will have on their economic resilience, requiring increased economic diversification to make them less dependent on oil and gas revenue (as pointed out in **IEA, 2018a**). Ensuring a universal buy-in, including development opportunities, is important also to avoid major geopolitical tensions that risk to emerge in their absence, and may eventually be inevitable (**Bordoff & O'Sullivan, 2022**).

One interesting possibility to facilitate an equitable and faster transition is offered by highly-utilised vehicles, discussed in Box 3. **The case of light and more affordable vehicles, spanning from e-bikes to microcars**, is also of particular interest, not only for their resource efficiency, but also because, in LMICs and when compared with conventional vehicle categories, these vehicle types can help embrace the ZEV transition while addressing capital availability constraints. It is therefore in the interest of both LMICs and HICs to make sure that the ZEV offer includes vehicles belonging to these categories, and does not only focus on the segments of the car market that can be sold with high margins.

FIGURE 20. SALES-WEIGHTED RESULTS ON BATTERY SUSTAINABILITY POLICIES, WITH COUNTRIES CLUSTERED BASED ON VEHICLE MANUFACTURING PROFILE, NET IMPORTS OF OIL/OIL PRODUCTS AND PER CAPITA INCOME



*Source: own assessment by the authors, based on information from Figure 15, data from **OICA, 2023a** on vehicle sales and complementary information for countries not individually represented in the OICA database, IEA energy balance tables, accounting for net trade of oil and petroleum products, combined **IEA, 2022c** and the World Bank's current classification based on countries' GNI per capita (**World Bank, 2023**).*

Right sizing of vehicles and batteries can indeed play a critical role in improving resource efficiency. In the case of cars, clear challenges emerge from a tendency by automakers in HICs and some of the major LMIC markets to shift towards Sports Utility Vehicles (SUVs), including EVs. This follows a desire to focus on high-value segments of the car market to maximise profit, particularly relevant in a context where shared mobility (enabled by digital technologies) may bring risks of a shrinking vehicle market and where the industry needs liquidity to invest in clean vehicle technologies (**ITF, 2021**). Solutions may include greater reliance on PHEVs, as long as policy can ensure that they can effectively be maximising all-electric driving, electric road systems, battery swapping, taxation differentiated by vehicle weight and regulatory requirements on battery size (which could take a form similar to the corporate average fuel economy standard, with battery capacity being the regulated parameter).

The electrification of transport in LMICs is also particularly attractive for two-wheelers, due to their low capital cost and limited power demand (both paired with lower barriers to market entry). In many Asian countries - such as Cambodia, India, Vietnam - two-wheeled vehicles account for as much as 60 to 80 percent of passenger-kilometres, making their electrification particularly relevant (**World Bank, 2022**).

BATTERY MANUFACTURING, SUPPLY CHAIN SUSTAINABILITY AND END-OF-LIFE MANAGEMENT

The discussion developed in earlier sections has shown that **battery manufacturing, supply chain sustainability and end-of-life management is clearly the area with the greatest policy gap** amongst all those reviewed here.[43] Reasons for this include both the novelty and the complexity of this subject for transport policymaking (in comparison with themes like energy efficiency and fuel economy that have been targeted by policy developments of different nature for decades, especially in HICs), since the increasing competitiveness of ZEVs (in particular EVs) is a fairly recent phenomenon.

Figure 20 adds to the earlier findings the following considerations:

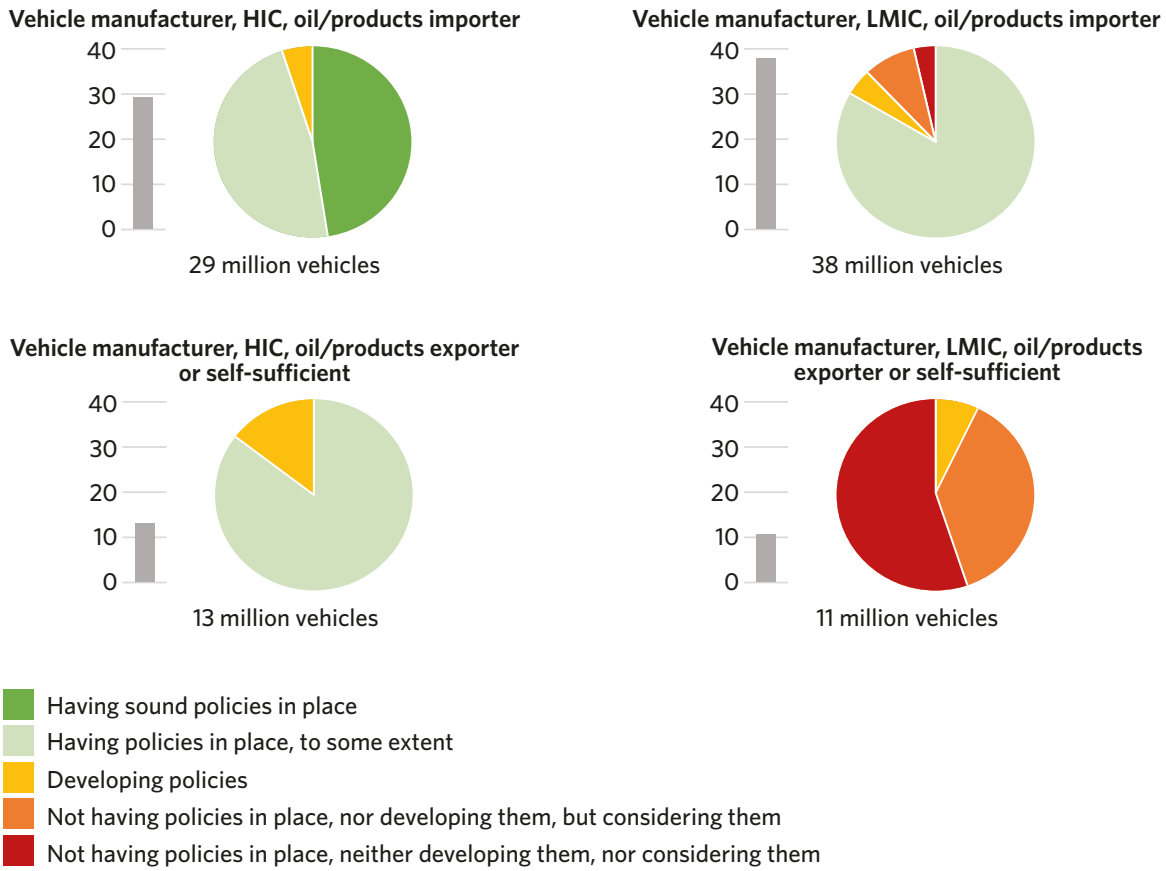
- Major car producing markets are amongst the cases where there have been the most extensive policy efforts so far, even if the EU is the only case with a very comprehensive policy instrument (the Battery Regulation), capable of addressing a wide range of challenges.
- Only some HICs have taken action on the topic of battery end-of-life management, among countries not having an automotive manufacturing industry. Policy action on batteries, from end-of-life management to supply chain sustainability, is clearly lagging in LMICs without a car manufacturing industry.
- As in the case of ZEV and related infrastructure, battery management policies are more advanced in oil importing countries (due to greater interest in energy diversification) than in oil exporting ones, especially for LMICs.
- The case with the deepest policy lag and the largest relevance in terms of size of the market affected is in countries with the presence of an auto manufacturing capacity and self-sufficiency or net oil/petroleum product exports. This is consistent with the prioritisation of the protection of existing interests over environmental and forward-looking anticipation of market transformations and confirms the criticalities already observed in the case of ZEV and charging infrastructure policies.

As batteries require proper end-of-life management to limit their environmental impact (including via material recycling, which is less energy intensive and better aligned with economic circularity) and as there are significant flows of second-hand vehicles being traded from HICs to LMICs (especially low-income countries), bridging the policy gap in this area will have a likely growing relevance.

Specific challenges exist for ZEV-related second-hand vehicle trade. These include:

- Second-hand electric vehicles - including from structural changes in the countries of origin, which could start including China, currently not a major exporter - could become a burden in markets without the capacity and infrastructure to repair and recycle electric vehicles and the batteries that power them.
- Limitations in the availability of material supplies (or at least the pace of scaling up extractive activities, and the timelines needed to initiate mining activities) could lead to stronger constraints on second-hand electric vehicle trade, with greater rates of retention of the vehicles in economies where they are first deployed, in comparison with ICEVs, at least for some time.
- ICEVs may lose value due to a rapid shift towards EVs, enabling increased access in LMICs at lower costs, resulting in faster motorisation and increased induced demand of fossil energy.

FIGURE 21. BATTERY SUSTAINABILITY POLICIES WITH VEHICLE MANUFACTURING COUNTRIES CLUSTERED BASED ON NET IMPORTS OF OIL AND OIL PRODUCTS AND PER CAPITA INCOME



*Source: own assessment by the authors, based on information from Figure 15, data from **OICA, 2023b** on vehicle production and complementary information for countries not individually represented in the OICA database, IEA energy balance tables, accounting for net trade of oil and petroleum products, combined **IEA, 2022c** and the World Bank's current classification based on countries' GNI per capita (**World Bank, 2023**).*

Addressing these challenges will be important, at once, to manage GHG and pollutant emission mitigation, energy efficiency and diversification and resource productivity/material efficiency.

Bridging this gap will not only have major implications for environmental aspects, but also - especially when it comes to policies related with the sustainability of the battery supply chains - clear impacts on development opportunities. The reason for this is that the alignment with supply chain sustainability requirements will be an enabler of access, for LMICs, to HICs markets (and therefore an important key to unlock both export and investment opportunities).

It will also be important that requirements regarding ESG performances of batteries and their supply chains are set in consistent ways globally, and - if global harmonisation is not achievable - at least across major markets. Harmonised safety and durability performances, also capable of avoiding technology picking, could complement this further. The reason for this call for a global harmonisation is that avoiding multiple standards is a crucial enabler of a pattern of development that is genuinely open to everyone. Not succeeding in achieving this will leave the door open to the prevalence of specific interests, with risks to slow down the global progress towards all the SDGs and the creation of lock-in effects in different areas of geopolitical influence.

Making sure that the policy gap on different aspects of battery manufacturing, supply chain sustainability and end-of-life management can be effectively bridged is more challenging than the case of policies focused on fuel economy improvements and/or the ZEV transition.[44] **This means that additional efforts are required**, in comparison with fuel economy and ZEV transition policies,

by countries leading the development of policies related with the sustainability of battery supply chains and end-of-life management, to ensure that the frameworks they adopted can facilitate an harmonised global transition.

Figure 21 shows results for battery policy frameworks based on weights associated with vehicle production volumes, differentiating between HICs and LMICs and oil/petroleum product importers and countries that are self-sufficient or exporters. The Figure confirms the observations seen in Figure 20, stressing the need to support LMICs with vehicle manufacturing capacity and oil/petroleum product exporters, or self-sufficient, to take a leap forward on the importance to prepare their industry for a policy-driven transition of the global automotive sector towards ZEVs. The Figure also confirms the need to make progress, even in HICs, on policies capable to fully cover battery supply chain sustainability requirements (including due diligence for the sourcing of minerals).

LOW-CARBON ELECTRICITY

Table 6 lists countries based on their policy action on the decarbonisation of electricity and related market reforms, in clusters related with the current carbon intensity of the electricity generation and the role that countries play or intend to play in battery manufacturing and the related supply chain.

TABLE 6. ELECTRICITY DECARBONISATION POLICIES AND RELATED MARKET REFORMS, RELATED WITH CURRENT CARBON INTENSITY OF THE ELECTRICITY GENERATION AND ROLE IN THE BATTERY VALUE CHAIN

		Carbon intensity of electricity production	Electricity decarbonisation policies and related market reforms
Current, emerging or prospective battery manufacturers	HICs	Very low to medium	**Canada, EU and EFTA, United Kingdom, United States**
		High and very high	**Australia, Japan,** Korea, Saudi Arabia
	LMICs	Very low to medium	**Brazil,** Mexico, Nigeria, Pakistan, **Russian Federation, Türkiye, Uganda,** Vietnam
		High and very high	China, India, Indonesia, Malaysia, Morocco, South Africa, Thailand, Uzbekistan
Others	HICs	Very low to medium	Chile
		High and very high	Seychelles, **United Arab Emirates**
	LMICs	Very low to medium	Argentina, Armenia, Cambodia, Colombia, Democratic Republic of Congo, El Salvador, Ethiopia, Ghana, Kenya, Mozambique, Paraguay, **Rwanda, Ukraine,** Zimbabwe
		High and very high	Azerbaijan, Bangladesh, Bosnia and Herzegovina, Cabo Verde, Dominican Republic, Egypt, Iran, Mauritius, Philippines, São Tomé and Príncipe, St Lucia

Note: Countries/economies with a role in the battery supply chain (or plans to have one) are in bold.

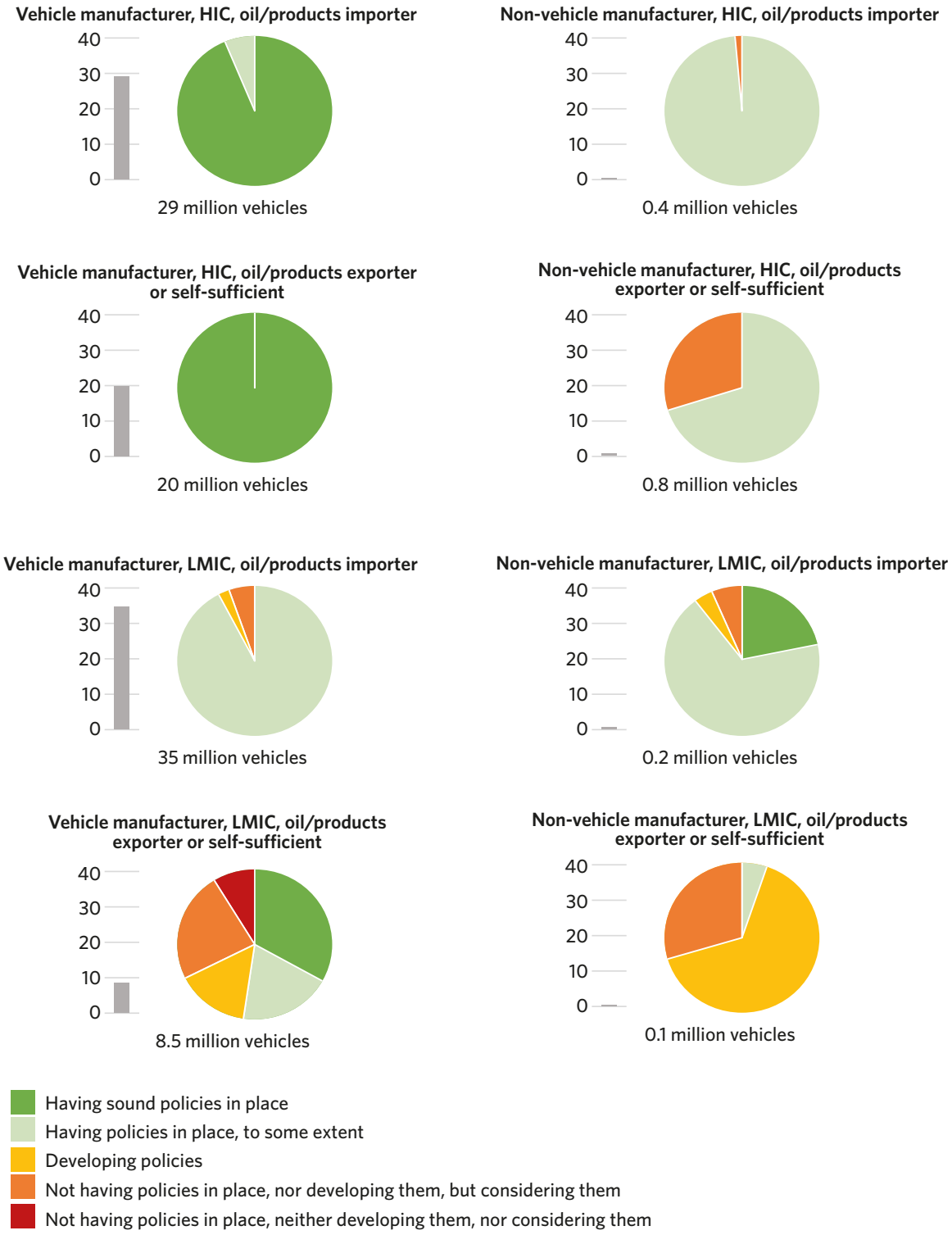
Legend:

Green	Having sound policies in place
Light Green	Having policies in place, to some extent
Yellow	Developing policies
Orange	Not having policies in place, nor developing them, but considering
Red	Not having policies in place, nor considering them

Source: compiled by the authors, based on the sources already cited in earlier Figures and Tables.

Notes: HICs = high income countries; LMICs: low and middle income countries; EU = European Union; EFTA = European Free Trade Association.

FIGURE 22. SALES-WEIGHTED RESULTS ON LOW-CARBON ELECTRICITY POLICIES, WITH COUNTRIES CLUSTERED BASED ON VEHICLE MANUFACTURING PROFILE, NET IMPORTS OF OIL/OIL PRODUCTS AND PER CAPITA INCOME

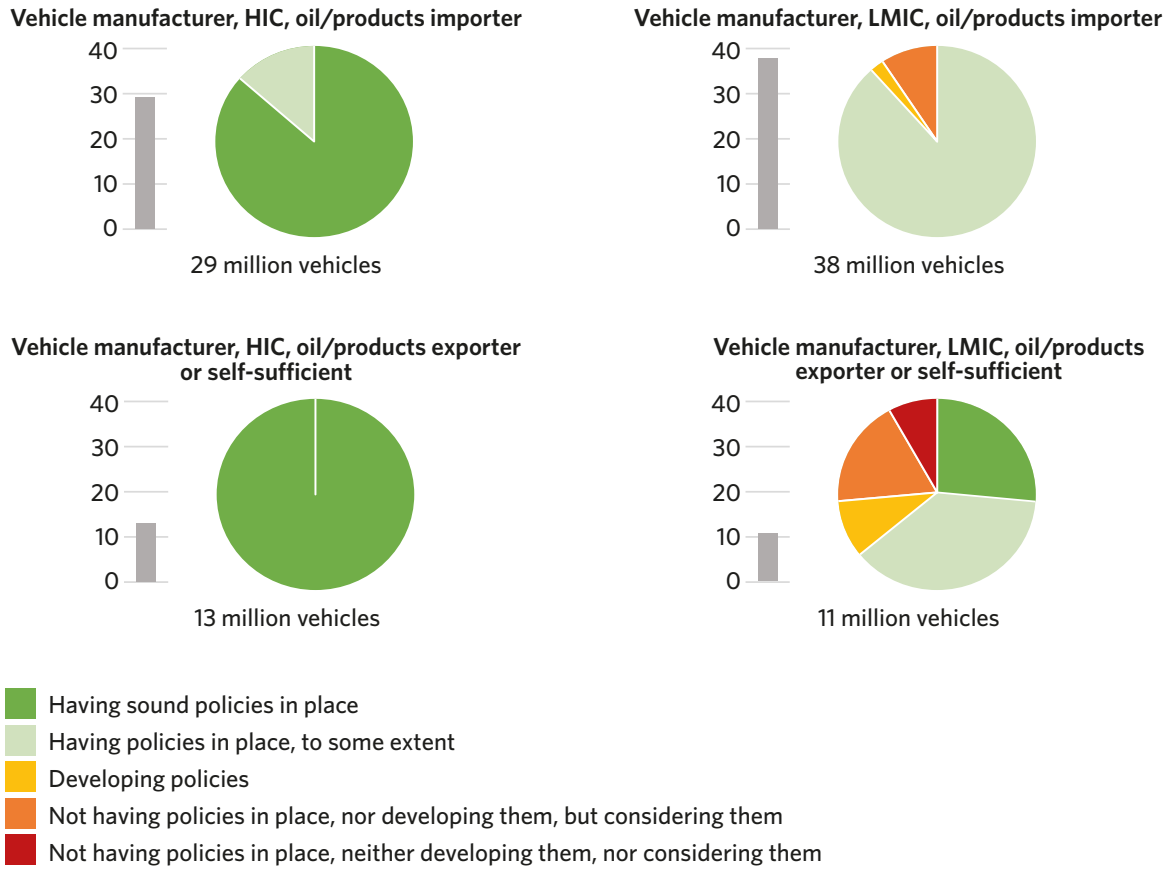


*Source: own assessment by the authors, based on information from Figure 13, data from **OICA, 2023a** on vehicle sales and complementary information for countries not individually represented in the OICA database, IEA energy balance tables, accounting for net trade of oil and petroleum products, combined **IEA, 2022c** and the World Bank's current classification based on countries' GNI per capita (**World Bank, 2023**).*

In principle, it is reasonable to expect that countries that developed policies to decarbonise their electricity systems are more likely to have lower carbon intensities per kWh produced. However, Table 6 suggests that the establishment of policies aiming to diversify and reduce carbon intensity of electricity generation does not necessarily follow a very clear pattern, if compared with actual carbon intensities of the electricity mix. Reasons for this include:

- A relevant role of some of the low-carbon electricity generation options (namely hydro) in early phases of the development process (as shown by examples in Latin America and Central Africa, where water availability has been abundant).
- Conversely, a relevant role of thermal (typically coal- or gas-powered) generation in places with high domestic fossil energy endowment (as shown by the case of South Africa, China, India and other Asian economies), only recently being mitigated by a significant increase in interest and investments in renewable electricity, given its lower electricity generation cost.
- Growing interest for other, decentralised, low-carbon electricity generation options (namely solar and wind, combined with stationary storage), especially for off-grid conditions (more common in low-income countries), but not limited to this (and therefore also relevant in HICs that tend to be paired with more integrated electricity grids).

FIGURE 23. PRODUCTION-WEIGHTED RESULTS ON LOW-CARBON ELECTRICITY POLICIES, WITH VEHICLE MANUFACTURING COUNTRIES CLUSTERED BASED ON NET IMPORTS OF OIL/OIL PRODUCTS AND PER CAPITA INCOME



*Source: own assessment by the authors, based on information from Figure 13, data from **OICA, 2023b** on vehicle production and complementary information for countries not individually represented in the OICA database, IEA energy balance tables, accounting for net trade of oil and petroleum products, combined **IEA, 2022c** and the World Bank's current classification based on countries' GNI per capita (**World Bank, 2023**).*

Figure 22 complements the overview of Table 6 adding weights based on vehicle sales. Both figures 22 and 23 (with the latter showing production-weighted, rather than sales-weighted) point towards a clear orientation of HICs with a car manufacturing industry towards policy action seeing a decoupling of electricity production from GHG emissions. This also is the case, but only to some extent (reflecting higher initial emissions per kWh or a slower pace of decarbonisation) in LMICs with vehicle manufacturing capacity.

The greatest criticalities are found in countries that are oil/petroleum exporters or self-sufficient. This is in line with earlier findings regarding ZEV and battery policies and represents once more a warning sign, since low-carbon electricity (and low-carbon energy more broadly) are emerging as important determinants of future developments for trade, including for (but not limited to) battery manufacturing.[45] From this perspective, **countries that have achieved a successful transition towards low-carbon electricity (and energy systems more broadly) are amongst those with the greatest chances to intercept opportunities to have access to export markets for their products.**

Making sure that all countries can effectively migrate towards this type of condition (as well as other ESG requirements) will need to be taken as a priority.

Due to the broad and multi-sectoral implications of these trade-related considerations, partnerships and international cooperation supporting a global transition towards an increased decoupling of economic activities and environmental impacts, adding to social and governance considerations, will not only be needed for transport-specific policies (like ZEV, infrastructure and batteries). They shall also be adopted for the support of a transition for the electricity generation and, more broadly, for all energy production and transformation facilities.

The identification of appropriate pairs of countries to structure cooperative activities internationally can build on a logic that is similar to the one used for the example in Figure 17. This consists in identifying partnerships by linking up HICs and LMICs that have already achieved significant progress in the decarbonisation of their energy production and transformation systems with LMICs (and eventually also HICs) that are still struggling to achieve this. Further commonalities (e.g. the presence of a vehicle manufacturing facilities, metal production and processing, or activities that are part of the battery value chain) are relevant to reinforce the effectiveness of these cooperation opportunities.

PRIORITIES FOR FUTURE ACTION ON AN INCLUSIVE ZEV TRANSITION

Actions fostering an inclusive ZEV transition would need to be framed in the support of an agenda that would enable achieving the SDGs and face the increasingly urgent climate emergency (**G20, 2022**). It is in this context that a G20 independent panel recommended measures to modernise how MDBs calculate their capacity to lend in support of development and environmental objectives.

The analysis developed in this section intends to help figure out what could be a constructive, multi-faceted response to this call. It builds on desk research and the indications offered by policymakers from the Global South, collated in a series of open answers in the survey.[48] These are:

1. Recalling key policy actions that enable the ZEV transition, adding to the policies described throughout the study. These include supply-side measures (to make ZEVs available), demand-side measures (to make ZEV part of the technology mix of vehicles in use), and policy tools regarding the decarbonisation of electricity systems.
2. Highlighting the need to frame the ZEV transition in a holistic development towards sustainable mobility. In this context, it calls on HICs to support LMICs to quickly embrace a holistic transition towards sustainability, including but not limited to a transition to ZEVs, for compelling reasons related with global planetary risks and opportunities for everyone to be better off (and therefore also in better conditions to keep financing development).
3. Underlining the importance of reducing the cost of capital for SDG- and ZEV-aligned investments in LMICs (and the critical role that MDBs play in this space), as a way to support their holistic transition towards sustainability.
4. Suggesting to leverage the potential of existing platforms of international cooperation to facilitate key policy developments in LMICs, paying specific attention to cases with deep policy gaps identified in Chapters 4 and 5 of this report.
5. Adding a specific call to consider the challenge of road user charges, likely needed to cover infrastructure development and maintenance costs, both needed to pay back investments made with MDB funding in infrastructure.

SET CLEAR PRIORITY AREAS FOR POLICY ACTIONS THAT WILL ENABLE THE ZEV TRANSITION

Policy action that helps kick-off and sustain the ZEV transition is a prerequisite to enable and ensure the economic viability of ZEV-related investments. Key policy tools have already been identified in the GFEI Zero Pathway report and other relevant work (such as the ICCT assessment estimating funding needs just cited), and are summarised in Table 7.

Due to the deep interconnections with the electricity system, policy priorities (not covered in Table 7) also include rules for the effective functioning of the electricity market, and in particular instruments enabling EV owners and other energy consumers - via intermediary entities capable of pooling demand from different end-users - to perform electricity demand response activities, increasing opportunities to shift charging demand away from peak periods and to integrate variable renewable energy resources into the generation mix, as well as reducing the cost of electricity (**IEA, 2019**; **ITF, 2021**).

Other ways of contributing to electricity demand management and reducing electricity prices include simple measures such as providing consumers with information and the use of battery swapping, which allows to spread charging over longer periods of time (rather than just when the vehicle is stationing next to the charger). Smart charging infrastructure can also allow grid operators to influence when vehicles charge, and potentially even integrate vehicle batteries as energy storage resources at the system level (**World Bank, 2022**).

The largest investments (and therefore funding requirements) paired with the ZEV transition need to cover an adequate scope of activities. These include:

- Vehicle purchase and fleet deployment
- Related charging infrastructure, including electricity network developments

The former may come from public and private entities, depending on the vehicle, whereas the latter are especially important for heavy vehicles, given their power demand. They could also be shared with other electricity end-uses and be mitigated by smart charging solutions, as long as policies and technologies allowing the use of vehicles as a resource to provide grid services are also deployed.

Other investments are also needed to support industrial development policies (e.g. grants, low-interest loans, loan guarantees, etc.). These are crucial for cases with the biggest risk of a growing divide with a transition towards SDG-aligned growth, in particular countries that are net exporters of oil/petroleum products, to help them diversify and seize opportunities.

TABLE 7. PRIORITY AREAS FOR POLICY ACTION TO KICK-OFF AND SUSTAIN THE ZEV TRANSITION

Policy group	Specific measures
Technical standards and regulations	Sockets, connectors, communication protocols Payment instruments Cross-border interoperability of chargers Test procedures and limit values for vehicle and battery safety and durability requirements First responders' guidelines
Information, communication	Demonstrations of ZEV technology Pilot projects to increase awareness
Clear milestones	Vision Targets (ICEV phase out, minimum charging infrastructure availability) ZEV and charging infrastructure roadmaps
Efficient levels of energy taxes and carbon prices	Removal of harmful and unsustainable subsidies for fossil fuels Fuel taxes (excise, VAT) Carbon pricing Rationalisation of fossil fuel taxes Regional harmonisation
Procurement Focus on specific vehicle segments	Publicly owned or tendered vehicles (including buses, government fleets) Two wheelers Three wheelers Taxi, ride sourcing Shared mobility
Economic incentives Differentiated taxation Taxation reforms	ZEV production/import ZEV purchase/acquisition Road user charges
Regulatory limits	CO_2 emissions or fuel economy regulations Pollutant emission regulations ZEV sales mandates Minimum charging infrastructure deployment requirements Minimum environmental and safety performance requirements for second hand imports
Green investment frameworks	Taxonomy of sustainable activities (tailored to ZEV, including vehicles and chargers) Green/climate bonds

Policy group	Specific measures
Trade policies	Import duties (and/or ZEV-related exemptions) Minimum requirements related with environmental and safety performance of batteries and/or vehicles - including second hand vehicles traded internationally ZEV-specific minimum requirements on safety and environmental performance - including second hand vehicles traded internationally Age limits Import restrictions (and/or ZEV-related exemptions) Carbon border adjustment mechanisms
Industrial development support for ZEV/charger manufacturing, assembly and for the development of resilient and sustainable supply chains	Grants, research funds and tax exemptions for R&D spending Co-investment by public entities, debt service reserves, government-held subordinated debt, credit insurance products for bond financing, and loan guarantees Conditional access to low-interest loans, conditional on specific attributes (performance based on environmental parameters, e.g. GHG emissions/km) Tax rebates and financial instruments aiming to reduce investment risks, conditional on the achievement of specific performance goals (e.g. energy and/or power density, durability of EV batteries, focus on zero-emission enabling technologies), integrating enforcement provisions (e.g. proof of sale and use of clean vehicles and energy) Economic incentives from export credit or investment insurance agencies for projects facilitating the development of supply/value chains for materials and components needed for clean vehicle production and/or clean energy supply
Workforce support	Technical training for ZEV manufacturing/assembly, maintenance, repairing, battery recycling and end-of-life usage, reuse, and material recovery

Source: elaboration by the authors based on **IEA, 2018b**; **ITF, 2021**; **GFEI, 2021**; *and* **ICCT, 2022a**.

FRAME THE ZEV POLICY ACTION IN THE BROADER CONTEXT OF A MOVE TOWARDS SUSTAINABILITY, AND IN A HOLISTIC DEVELOPMENT TOWARDS SUSTAINABLE MOBILITY

Enabling a successful mobilisation of investments for the ZEV transition in LMICs would require to quickly bridge the divide between current conditions and those that would be coherent with SDG-aligned investments.

The analysis developed in this report flags the importance of taking action to bridge key policy gaps. It underlines the sustainability of battery supply chains and end-of-life management as an emerging critical area, integral to the ZEV transition and an affordable and low-carbon electricity mix. Allocating specific funds and structuring international assistance work to help bridge these policy gaps (some of which are also due to the novelty of the policy developments, even in HICs)[49] would be a likely priority.

A key rationale for making of this effort a first concern is grounded in the intrinsic meaning of 'enabling a just transition'. The concept recognises that the transition towards environmentally sustainable economies is coming hand in hand with major social challenges, such as the displacement of workers, job losses, and higher energy and commodity prices. These are disproportionately impacting low-income households and vulnerable groups in HICs (**EUR-lex, 2021**; **Systemiq, Club of Rome, & Open Society European Policy Institute, 2022**), and entire communities in LMICs.

Taking action to bridge these policy gaps shall not only help solve the deepest issues identified, but it should also be part of a broader effort by HICs to support LMICs (especially exporting countries) to transition towards sustainability in a holistic way. A key reason for this is that LMICs risk facing barriers if HICs shift towards a development model that aims to generate value in a sustainable way (e.g. through the circular economy, ecosystem services or decarbonised and dematerialised, outcome-based services).[50] **A lack of support for LMICs to quickly develop policies enabling their transition towards low-carbon technologies - including but not limited to ZEVs - risks increasing geopolitical tensions due to reduced access to major markets, as HICs' development strategies are shifting towards a better alignment with the SDGs.**

Efforts from HICs to support LMICs in this integrated transition could come in the form of an international "just transition fund" (**Systemiq, Club of Rome, & Open Society European Policy Institute, 2022**), in analogy with policy developments that have started to take place within the EU. Additional action is also needed to facilitate technological transfer to ensure that LMICs can successfully leapfrog towards SDG-aligned technologies, also with the aim to facilitate a fair distribution of the value created in supply chains needed to sustain transport decarbonisation.

While the transition towards ZEVs and low-carbon electricity is a key component of a reorientation of global development towards sustainability, it is important not to lose sight of the fact that in order to further reduce emissions, the transition in vehicle powertrain and energy technologies shall be complementing changes taking place in the design and planning of settlements and transport infrastructure.

In urban environments, this includes the promotion of land use planning to achieve compact urban form, the co-location of jobs and housing, the support for public transport and active mobility and other measures enabling a better alignment with the SDGs beyond the transportation sector - e.g. for buildings and material consumption, more broadly (**IPCC, 2023**).

ZEV policies should therefore be part of an integrated strategy for sustainable mobility, taking it as one of several complementary approaches supporting the decarbonisation of road transport. **ZEVs are just one way to improve the sector's carbon footprint**. This way may not necessarily be the most cost-effective one, nor the least resource-intensive. **It needs to be considered alongside other measures, such as the improvement of overall fuel efficiency of the vehicle fleet, and combined with other measures to manage travel demand and minimise emissions and environmental impacts beyond those imputable to vehicle manufacturing, use and energy/ fuel production, such as those associated with infrastructure construction.**

Taking this into consideration, HICs should support investments to deploy the infrastructure needed by a more electrified, integrated and intermodal mobility system in LMICs, rather than focusing - as they did in the past - primarily on the expansion of carbon-emitting transport for the facilitation of trade and productivity (**Systemiq, Club of Rome, & Open Society European Policy Institute, 2022**).

Making sure that this shift actually happens is crucial to narrow the chances to see increased geopolitical risks due to a widening gap between HICs and LMICs on sustainability, and therefore also what can bring the global community closer to greater chances of a collective development, only possible with an increased decoupling of economic activities from health and environmental impacts.

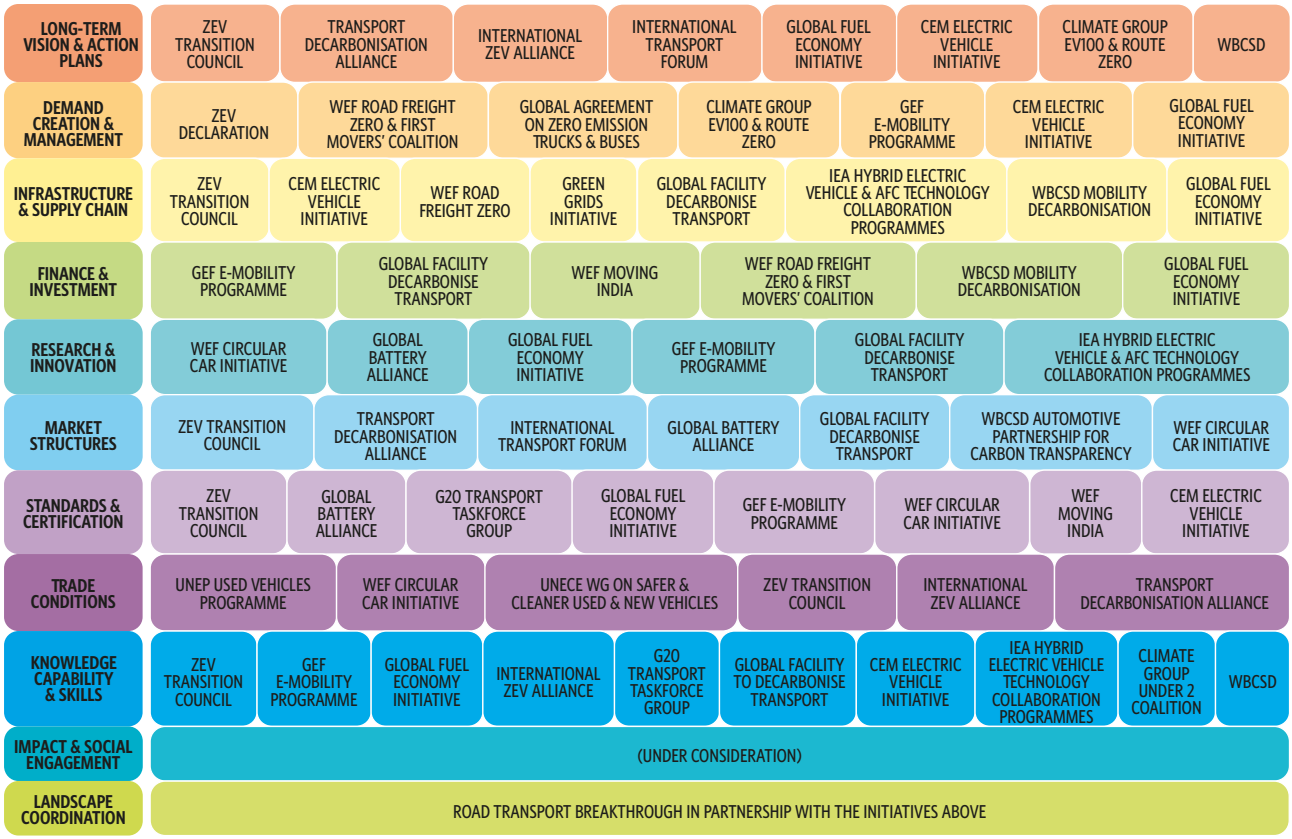
In addition to measures to decarbonise road transport, some LMICs have highlighted[51] that decarbonisation of other transport modes (such as aviation and maritime) is already a priority in their agendas. Alternative fuels – including e-fuels – will play a significant role in this space, due to greater challenges for cost effective electrification (unlike in the case of road transport, given the better cost competitiveness of direct electrification).[52]

REDUCE THE COST OF CAPITAL FOR SDG- AND ZEV-ALIGNED INVESTMENTS IN LMICS

The cost of capital in LMICs makes otherwise bankable projects unviable, pointing to a role for MDBs as both investors for infrastructure development and potential mobilisers of private investment by sharing risks such as credit risk, off-taker risk, political risk, and liquidity risk (**Climate Policy Initiative 2023**).

Due to challenges for LMICs to get access to affordable capital and the possibility for MDBs to borrow and at very favourable terms (with AAA rating in most cases), an increase in the lending

FIGURE 24. LANDSCAPE MAP OF ROAD TRANSPORT DECARBONISATION INITIATIVES



Source: ***Climate Champions, 2022****.*

capacity of MDBs for projects characterised with a better alignment with the SDGs could be instrumental to facilitate access to affordable capital for all countries.

To mobilise the volumes of private finance needed for a sustainable future and reduce cost of capital, guarantees that investments made can be effectively SDG-aligned (a key condition to ensure that economic development takes place in a way that is decoupled from adverse health and environmental impacts, including on GHG emissions) will need to be deployed at a greater scale (**Climate Policy Initiative, 2023**).

The development of an internationally agreed, science-based international classification system, establishing a list of environmentally and socially sustainable economic activities (a taxonomy) is a likely prerequisite to enable an effective increase of SDG-aligned MDB lending (**Systemiq, Club of Rome, & Open Society European Policy Institute, 2022**).[53] Importantly, asymmetries related to taxonomies and large data gaps, absence of common taxonomies, inadequate classifications for sustainable investment have been underlined, in tandem with home bias considerations, and an overlay of other risk factors and externalities, as important obstacles to SDG-aligned lending by MDBs themselves (**IMF, 2022**).

As the EU work demonstrates, a taxonomy of sustainable activities would most likely include ZEVs, low-carbon electricity and charging infrastructure (**European Commission, 2023**). By doing so, it would be effective to stimulate the ZEV transition, both on the supply side (mining, processing of materials, battery manufacturing, low-carbon electricity production and ZEV production) and on the demand side (vehicle purchase, low-carbon energy use).

Other tools, capable of tracking resource footprints for mineral resources and their impacts, could strengthen a taxonomy of environmentally and socially sustainable economic activities (Systemiq, Club of Rome, & Open Society European Policy Institute, 2022). For ZEVs, these would be especially important in the case of battery value chains.Leverage existing platforms to facilitate key policy developments in LMICs.

Platforms facilitating international collaborations, including in particular those included in the review developed for the Breakthrough Agenda report of 2022 (**Climate Champions, 2022**) and reported in Figure 24 for the case of road transport[54] are well positioned to support exchanges between governments willing to share best practices.

Key reasons for this lie in the fact that they have already developed extensive networks and gathered internationally subject matter experts. These platforms are effective to offer opportunities to open the conversation not only amongst government officials, but also with other important stakeholders, including MDBs, intergovernmental organisations, private sector, academia, and NGOs.

As a general rule, it will be essential to make sure that these initiatives develop in a way that is more inclusive towards LMICs, bringing together governments to foster sectoral dialogues and integrating dedicated activities (including financial support) to bridge an important capacity gaps for LMIC policymakers, reducing the risk to find resistance to the case for climate policy.

One possible way to leverage existing platforms to support LMICs to accelerate their alignment with the SDGs and the ZEV transition is the organisation of follow-up communities, using the findings of the clustering exercise developed here to maximise chances to make them compelling for LMIC policymakers and effective to achieve the acceleration of change, also thanks to scale and replication effects. Examples of cases where the clustering criteria exercise can help allocate funds more efficiently by two main groups include:

- Activities by national development agencies, who can more easily identify which countries to connect with if they have not done so far, and which they can support with their own past experiences.
- Multilateral donors and initiatives in general, given their capacity to work across countries and jurisdictions, paired with a desire and/or mandate to facilitate exchanges and mutual learning.

ELABORATE A COMPELLING VALUE PROPOSITION TO TRANSITION TOWARDS ZEV IN LMICS AND PROMOTE THE ENHANCEMENT OF CHARGING INFRASTRUCTURE AND LOW-CARBON ELECTRICITY POLICIES

Regarding ZEV policies, charging infrastructure and low-carbon electricity, the focus should be on the elaboration of a compelling value proposition to transition vehicles, electricity supply and grids in the LMICs. This is essential to ensure that LMICs can benefit from and contribute to the transition of the road transport sector that has already started HICs and MICs (as shown in Figure 2 and in the policy analysis of Sections 5 and 6).

Specific opportunities could come from the possibility to leverage like-to-like situations (within squares of Figure 17) across countries, drawing on best policy practice and business models, and adapt them to local contexts in countries that have less ambition. Other opportunities could arise from synergies identified in Figure 17, reflecting alignment with respect to vehicle manufacturing and oil/petroleum product trade profiles of HICs and LMICs.

Platforms for international collaborations can be the facilitators of these exchanges, with the additional advantage of the possibility to leverage the expertise they have been managing to gather.

Clear opportunities are offered by the option to accelerate the transition of highly utilised vehicles such as buses, minibuses, taxis, ride-sourcing vehicles, two- and three wheelers where they are used as a form of informal public transport, thanks to the cost-effectiveness and financial viability of their electrification. Other opportunities lie in the early transition of two-wheelers, thanks to their lower affordability barriers, important in capital-constrained households of LMICs.

Complementary measures may also focus on right sizing vehicles and batteries, favouring light vehicles (including those in the L-category[55]) over large ones (including SUVs), as light vehicles also help bridge affordability challenges (something that is also not absent in HICs).

For oil/petroleum product exporting countries, it is also crucial to seek consensus on an economic diversification strategy, leveraging opportunities to maximise opportunities to rely on resources other than fossil fuels.

ENSURE THAT ALL WORLD REGIONS DEVELOP BATTERY RECYCLING CAPABILITIES, AND ALL COUNTRIES ESTABLISH REGULATORY STANDARDS FOR THE END-OF-LIFE MANAGEMENT OF BATTERY MATERIALS AND THE SUSTAINABILITY OF THEIR SUPPLY CHAINS

International cooperation and initiatives will need to be reinforced regarding the topic of batteries, their end-of-life management and the sustainability of their supply chains.

Batteries have been defined as the most critical barrier for the development of EV by the World Bank, not only due to their cost, but also because they are subject to a high degree of market concentration and hostage to bottlenecks in the supply chain of the minerals from which they are made (**World, Bank, 2020**).

Aligning battery and EV material supply with the SDGs is one of the actions most subject to policy gaps. It is also of crucial importance to risk to geopolitical tensions, due to a widening division between HICs and LMICs in their path towards a better SDG alignment.
Beyond SDG alignment of ZEV policies, enforcement of the United Nations' Universal Declaration of Human Rights (**UN, 1984**) will be indispensable for an ethical transition to ZEV. The integration of voices from the communities most affected by this change (such as low-income workers, indigenous peoples, women) will be key to an inclusive and just transition.

Some of the most relevant fora currently active on this topic, worth being reinforced, include:

- The Global Battery Alliance (listed in Figure 18), a partnership multi-stakeholder platform mobilised to align battery production not only with green energy, but also with safeguards for human rights, health and environmental sustainability (**GBA, n.d.**).
- The Circular Cars Initiative of the World Economic Forum (also listed in Figure 18), focused on emissions embedded in vehicle materials, which will grow in importance in tandem with powertrain electrification, and paying specific attention to the maximisation of materials efficiency and resource productivity (**WEF, n.d.**).
- The activities of the Organisation for Economic Cooperation and Development (OECD) on responsible business conduct, aiming to encourage companies to incorporate social, human rights and environmental considerations into the way they do business, anywhere in the world, and including work specifically focused on batteries and their supply chain (**OECD, n.d.**).
- The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (**IGF, n.d.**), fostering governments' ability to build and administer mining tax systems to secure their fair share of revenues from their country's mineral resources, preventing the risk that increased competition for foreign investments between many LMICs triggers a "race to the bottom" of taxes as governments offer tax cuts and deregulations to attract investments (**Systemiq, Club of Rome, & Open Society European Policy Institute, 2022**).
- The Natural Resource Governance Institute (**NRGI, n.d.**), also aiming to ensure that mineral-rich countries achieve sustainable, inclusive development.

In a 2021 report, following the proposal of an EU battery regulation and before its finalisation, Transport & Environment also flagged the importance to consider both human rights and environmental standards, proposing a range of recommendations of the best environmental instruments available internationally to do so (**T&E, 2021**). Making sure that LMICs have better chances to engage with these fora, and where it is not the case already, gain exposure to these activities, will also be instrumental to enable collective progress.

Following an initial phase of ZEV development grounded on primary resource extraction, and as the stock of electric vehicle batteries in circulation starts to expand, it will become increasingly feasible to recycle batteries extracting further value from their mineral content (**World, Bank, 2020**). Ensuring that LMICs also have capacity to develop battery reuse and recycling capabilities will have a growing importance to enable a resource efficient use of battery materials globally and reduce the LMIC exposure to price volatility of primary battery materials. The establishment of regulatory standards and procedures improving the end-of-life treatment of battery materials, at the national and international level, as well as investments in material processing facilities set in place with regulations that extend producer responsibility to battery recycling, are also good options to be pursued by HICs to facilitate progress in LMICs regarding the development of a battery end-of-life management and recycling industry (**World, Bank, 2020**).

ADDRESS ISSUES RELATED WITH SECOND-HAND VEHICLE TRADE

Regarding second hand trade, HICs funding can support the improvements in several axes of action:

- The first is improved access to data, enabling a better understanding of the phenomenon, currently well understood but poorly documented due to limited information.
- The second is the development of a stronger framework enabling the mutual recognition of technical inspections, paired with the digitalisation of the information regarding vehicles traded internationally and reaching the end of their useful life.
- The third is stricter regulation of trade flows, taking into account he need to balance the advantages that fewer exports from HICs could have to accelerate the transition/leapfrogging of mobility systems in LMICs and the disadvantages that the same reduction in second hand vehicle trade could have on affordability of enhanced access to mobility and environmental impact, since it could trigger demand for ICEVs from other producing countries which have potentially less strict emissions regulations (**Systemiq, Club of Rome, & Open Society European Policy Institute, 2022**).
- The fourth refers back to policies aiming to deal with the sustainability of batteries, in particular with respect to end-of-life, and the need to ensure that LMICs can successfully develop an infrastructure and an industry to repair and recycle electric vehicles and their batteries.

International collaboration will be particularly important to ensure better coordination between exporters and importers regarding the mutual recognition of roadworthiness certificates and their digital records.

A key example is provided by EUCARIS, the European car and driving licence information system, which could facilitate the exchange of vehicle technical data and reduce the need for inspections of second-hand vehicles in receiving countries, guaranteeing greater reliability and lowering risks of fraud. This could first take place for trade originating in the EU. If adequately developed internationally (e.g. in the framework of the World Forum for the Harmonization of Vehicle Regulations of the United Nations), it could become relevant also beyond that.

Further work needs to focus on some of the new provisions included in the European Battery Regulation, being finalised following a recent political agreement, and integrate aspects related with the traceability of battery materials and the "battery passport", with positive spillovers for the emergence of a battery management industry also in LMICs. The European Commission, having laid out ground-breaking work with the battery regulation (especially regarding human rights, building on the OECD work), is likely best positioned, amongst all governments, to take a leadership role in this context.

EXPLORE ROAD USER CHARGES AS A SOLUTION TO FINANCE THE ZEV TRANSITION

A specific challenge requiring LMIC support the case of a transition towards road user charges. These can be a policy solution to make up for lost fuel-duty revenues and adequate pricing of vehicle use (**OECD, 2019a**; **ITF, 2021**). They would also be important, with a ZEV transition, to cover infrastructure development and maintenance costs, both needed to pay back investments made with MDB funding, and also to handle some revenue shortfalls that could derive from a transition to EVs.[56]

The shift to road user charges is likely to be complex, since governments need to find the balance between stimulating innovation and the technology transition, while also addressing the issue of revenue shortfalls and the impacts of road transport (**ITF, 2021**). Road user charges need to avoid increases in vehicle use driven by the lower travel costs of EVs, while maintaining incentives to switch to EVs and limiting social equity impacts. This complexity calls for a gradual shift, as well as the establishment of a solid technological basis for managing the transition, along with clear communication between stakeholders (including individuals that will adopt ZEVs) that will be affected by the change.

The presence of several other reasons to adopt road user charges further strengthens their appeal, but there are aspects that need to be considered further to make sure that this transition is also viable in LMICs. One, in particular, deserves greater attention: the application of road user charge would be significantly facilitated by a digital transition. Major work has been undertaken in HICs in this respect, with global navigation satellite system (GNSS) systems and integrating greater connectivity features on vehicles and road infrastructure. Enhancing HIC support to make sure that these developments are also viable in LMICs, or finding simplified and less technologically sophisticated alternatives, will be important to enable an economically sustainable transition towards ZEVs globally.

ANNEX I: BACKGROUND ON PARTNERS INVOLVED

Formed in 2020, the **ZEV Transition Council** (ZEVTC) is made up of governments and representatives from some of the world's largest and most progressive automotive markets. It is a political dialogue that aims to accelerate the transition to ZEVs, in line with the Paris Agreement, and is also one of the key international collaborator fora under the Glasgow Breakthrough on Road Transport (GBRT), which was launched at COP26. The GBRT has the aim of establishing a global process for measuring progress against making ZEVs the new normal by making them accessible, affordable, and sustainable in all regions by 2030.

As part of this effort, the ZEVTC set up an International Assistance Taskforce (IAT) in 2022. As a new strategic pillar, it aims to ensure that no country or community is left behind by coordinating a more tailored, impactful, and effective offer of development assistance, and by providing evidence-based and action-focused recommendations to the ZEVTC on how and where the international offer can be strengthened. The ZEVTC IAT has three working groups: the Country Projects and Partnerships Working Group (CPPWG), the Strategy and Coordination Working Group (SCWG), and the Knowledge Sharing and Signposting Working Group (KSSWG).

The CPPWG intends to support the global ZEV transition by mapping and identifying gaps and alignment opportunities in existing architecture of instruments aiming to facilitate a ZEV transition, with a focus on the needs of LMICs. The group is led by Co-Chairs Sheila Watson (FIA Foundation) and Sudhendu Jyoti Sinha (Government of India).

The **FIA Foundation** is an independent, UK registered charity which supports an international programme of activities promoting road safety, the environment and sustainable mobility. It works closely with grant partners to shape projects and advocate to secure change in policy and practice.

The **Global Fuel Economy Initiative** (GFEI) was founded in 2009 with the purpose of promoting and supporting government action to improve energy efficiency of the global light-duty vehicle fleet. Ever since, GFEI has highlighted how cost-effective investments to improve light-duty fuel economy lead to multiple benefits, including saving fuel, money and reducing CO_2 emissions. GFEI has assisted policymakers from over 100 countries in promoting greater fuel economy.

The **Institute of Transportation Studies at the University of California, Davis (ITS-Davis)** is one of the leading university Centres in the World on sustainable transportation, hosting the US National Center on Sustainable Transportation (awarded by the U.S. Department of Transportation) since 2013 and managing large research initiatives on energy, environmental, and social issues.

ANNEX II. METHODOLOGY

This project began with outreach to around 25 partners[57] of the ZEV Transition Council and the GFEI in October and November 2022.

Our goal was to kick off informing this network of partners about the study and get their initial feedback on the status of ZEV policies in LMICs, learn from past work done on this space, and explore the possibility of tapping into their networks of country officials to have them give their say to shape the way low-carbon vehicles are deployed globally. It was a priority for us to involve policymakers to avoid giving policy advice unsuited for countries beneficiaries.

With these inputs in mind, we developed an online survey aimed at studying how to bridge the transition gap toward ZEVs globally. The questionnaire had a different set of questions depending on the respondent's expertise and role in the ZEV transition space.

We targeted four main groups: policymakers working at the national level; policymakers working at the regional or local level; staff from MDBs and DAs; and staff from NGOs. We also opened the survey to professionals working in ZEV space from the private sector. Each of these groups had a tailored version of the survey, so as to make the most of their inputs, while parts of the questions were common to all groups.

The survey was first shared on 25 November 2022, and it was open until 31 December 2022. It was available in English, French, Spanish and Portuguese. During those six weeks, we organised six explanatory calls - in different languages - to give a chance to respondents to know more about the objectives and rationale behind the project, as well as to let them resolve any doubts/share their views prior to taking the questionnaire.

We collected a total of 109 answers. Out of these, 31% of respondents were policymakers from LMICs (25% working at the national level plus 6% at the regional or local level); 20% were staff from international organisations and multilateral development banks; 30% were staff from NGOs and development agencies. The remaining 18% were mostly from the private sector.

Inputs received have been instrumental to provide an initial basis, complemented by extensive desk research, for the development of Chapter 4 of this report, on the Status of the ZEV policy action.

ENDNOTES

1 Please refer to *Annex II: Methodology* for further information on the survey.

2 Hereafter Korea, for ease of reading.

3 The authors recognise that not all segments may provide the opportunity to leapfrog, yet it is important to capture those leapfrogging opportunities that already exist and plan for those.

4 Including Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs), as long as they drive in all-electric mode.

5 An accelerated ZEV transition in the Global South could reduce global transport-related emissions by 51% by 2050, compared to 2020 levels (**ICCT, 2022a**).

6 As 99% people living in urban areas breathe air with pollution levels deemed unhealthy (**WHO, 2022**).

7 Many countries are taking actions to take a central role in the EV production chain, ranging from investments in research & development (R&D) and capacity building related to ZEV uptake and infrastructure to boosting innovative business models that are better equipped to local needs (**ICCT, 2022a**). EVs local production is both an investment and a chance to promote the creation of green jobs.

8 Despite the need for policy action to ensure that these are aligned with environmental and sustainability goals, as shown by the case of ride hailing and shared micro-mobility (**ITF, 2020**).

9 Total cost of ownership is lower for e-buses in most cases, but not in all, as it depends on evaluation methodologies, time frames and data used for the assessments.

10 Especially when renewable electricity (produced by hydro, solar and wind) is the primary form of energy in the energy balances.

11 This target includes hybrid vehicles, plug-in hybrid vehicles (PHEVs), battery electric vehicles (BEVs), and fuel cell electric vehicles (FCEVs).

12 Definitions of ZEVs vary among studies and countries. In line with California's Advanced Clean Car II Program (**CARB, Cars and Light-Trucks are Going Zero - Frequently Asked Questions, n.d.a**), ZEVs discussed here include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell electric vehicles (FCEV). To a large extent, in current market conditions these vehicles consist of electric vehicles (EVs, including BEVs and PHEVs). The discussion is not solely focused on zero direct emissions (anyway not applicable to PHEVs), but it also extends to upstream emissions from vehicle/ battery production and electricity generation. Due to the low market penetration, infrastructure-related considerations are focused on EV chargers.

13 Despite a call for caution by a group of developing nations to avoid measures that might not be understood by rating agencies in positive light (**FT 2023**).

14 For more information on the survey, please refer to *Annex II. Methodology.*

15 These include 51 individual countries, plus those of the European Union (EU) and the European Free Trade Association (EFTA), totalling 82 countries. For ease of reading, EU and EFTA countries, i.e. countries in the European Economic Area (EEA) plus Switzerland, will be treated as a single entity (EU and EFTA). Indicators for this group will not differentiate across specific countries.

16 For a list of countries generally associated with the Global South concept, see (**FCSSC , n.d.**)

17 Based on World Bank's current classification based on countries' GNI per capita(**World Ban k, 2023**). All references to LMICs throughout the report encompass three subgroups of the World Bank's classification: low-income economies (with a GNI per capita of USD 1,085 or less in 2021); lower middle-income economies (with a GNI per capita between USD 1,086 and USD 4,255 in 2021); upper middle-income economies (countries with a GNI per capita between USD 4,256 and USD 13,205 in 2021). capita between USD 4,256 and USD 13,205 in 2021).

18 See (**Accelerating Zero Coalition, n.d.)**.

19 Further details on the survey are provided in *Annex II. Methodology*

20 Percentages are based on the latest data available from the World Development Indicators of the World Bank for population and Gross Domestic Product.

21 This percentage refers to new four wheeled vehicles. It is calculated on the basis of the latest data available for all vehicle sales from the International Organization of Motor Vehicle Manufacturers (**OICA, 2023a**) and on complementary data compiled by the authors for countries not individually covered in the main data source.

22 More information on the ZEVTC can be found in *Annex I: Background on Partners involved.*

23 The CPPWG intends to support the global ZEV transition by mapping and identifying gaps/ alignment opportunities in existing architecture of instruments aiming to facilitate a ZEV transition, with a focus on the needs of LMICs and existing instruments at the country level.

24 As explained in *Annex II. Methodology*.

25 These include the continued use of a range of policy tools, including: the removal of fossil fuel subsidies; the use of fossil fuel taxes and carbon pricing mechanisms; tightened regulations for tailpipe CO_2 emissions and the carbon content of fuels; and economic incentives for energy efficient vehicles. They also include additional policy tools, specifically focused on ZEVs: the development of technical standards; public procurement programmes; power sector reforms allowing optimisation of EVs and renewable or low-carbon electricity; economic measures and regulatory requirements stimulating demand for electric vehicles (EVs) in the market and the deployment of the charging infrastructure that they need; policies aiming to ensure that the materials required for batteries and renewable electricity are available and sustainably sourced and handled at the end of their useful life; that potential shortfalls in government revenues from a shift away from fossil energy can be managed; and that the implications of this technology transition (along with the digital one) on jobs can result in net benefits for the workforce.

26 These have already set strong targets and made considerable progress in adopting EVs. These include parts of Europe (such as Nordic and other northern European countries) and parts of other countries (such as California and Quebec).

27 These include major vehicle manufacturing countries that have either set strong targets or set policies that imply such strong targets.

28 These are non manufacturing, primarily importing countries with pro-fuel efficient and/or pro EV policies for example through pricing, economic incentives and/or regulatory requirements.

29 This includes passenger cars, including SUVs, light commercial vehicles and, in regions where they are relevant, pick-up trucks.

30 The estimate comes from **Honda, 2022a** and **Honda, 2022b** and it excludes electric-assisted bicycles.

31 A key example of this is visible in the recent announcement by the Government of Indonesia to set aside half a billion USD to support electric motorcycle sales (**Reuters, 2023**).

32 Including countries in the European Economic Area, Switzerland and the United Kingdom. Data sources are listed in the footnote of Figure 3.

33 This is due to net savings in terms of total cost of ownership, better features in terms of energy security and lower climate impacts, spurring a wide range of policy actions and leading to increased investments.

34 This can leverage the low-cost of second-hand vehicle imports and can enable a faster transition, but it requires the development of technical specifications to add scale to technical feasibility..

35 However, and as further discussed later, Saudi Arabia is investing in electric vehicle manufacturing (**Grimes, 2023**).

36 Some of SIDS in the Atlantic - namely São Tomé e Príncipe - are also bound to be net oil exporters (**International Trade Administration, 2022a**).

37 For more information on the survey, please refer to *Annex II. Methodology.*

38 These include differentiated taxation for energy efficient vehicles or the combination of taxation and rebates on best performing vehicles (feebates), the removal of fossil fuel subsidies, the introduction of carbon pricing mechanisms and fuel taxes based accounting for differences in terms of fossil carbon content.

39 Integrated in the European Union, in this assessment, and represented by EU/EFTA average, in figures.

40 Based on data from Sweden (**Nurdiawati & Agrawal, 2022**) and the USA (**McKinsey, 2023**).

41 The differences between countries that adopted fuel economy policies (namely the inclusion of major oil exporters such as Saudi Arabia and the United Arab Emirates) and those that did so on ZEVs (where these same countries have not made as much progress) are a clear indicator of this.

42 According to the assessment summarised in Table 5.

43 This is mirrored by other policy instruments, such as those targeting battery durability or fire codes, not reviewed in detail, but still having high relevance.

44 The reason for this is the lower degree of development of this type of policies in HICs and large LMICs (as they are often also major vehicle markets, and large-scale manufacturers). Using the approach adopted for the construction of Figure 17, consisting in links between countries that already have a solid policy framework in place and others that do not have it, yet, would leave some of the boxes on the left empty.

45 These considerations, developed here around the example of the battery value chain, are not only restricted to it. They apply more broadly to other energy intensive industries, with repercussions on a variety of products and services. Key examples also include the production of materials widely used in vehicle manufacturing, such as steel and aluminium.

46 Across African countries - such as Ethiopia and Ghana - buses account for some 40 percent, which again may be a good case for electrification. By contrast, in many upper-middle-income countries— such as Brazil and Türkiye— four-wheel vehicles account for more than 80 percent of passenger-kilometres travelled (**World Bank, 2022**).

47 This is a case that could be effectively bridged by development funding. One more case also relevant for this type of funds is the deployment of capacity to manufacture vehicles and components locally, as this would be likely to come with long-term benefits in terms of job creation. Near-term equity impacts could be effectively addressed, in this case, if investments in local manufacture were to be oriented with priority towards light vehicles (such as e-bikes, two wheelers and possibly other innovative forms of light e-vehicles, such as e-scooters and "low speed electric vehicles" in China).

48 Please refer to *Annex II: Methodology* for more information on the survey.

49 Particularly relating to supply chain sustainability and transparency.

50 Drivers of a shift to this type of development model are both in the environmental and the economic development narratives, since greater decoupling between economic activity and its environmental/ health impacts opens up greater opportunities for growth - notwithstanding that the extent to which this could happen is up for debate (see for instance **Liebreich, 2018** and **Dietz, 2018**).

51 In the above-mentioned survey. This is further explained in *Annex II. Methodology.*

52 E-fuels are subject to cost, technology readiness and energy efficiency challenges, limiting their capacity to contribute at scale to the transition in the very near term. Limitations remain also in the longer terms if e-fuels are compared with direct electrification, in all road modes, due to the better cost competitiveness of direct electrification, thanks to better energy efficiency and lower operational costs, especially for highly-utilised vehicles. The prospects of cost reductions for hydrogen and electricity production in countries with high renewable energy endowment, as well as the ease of handling, make e-fuels a relevant option for decarbonising transport modes that cannot shift towards direct use of electricity due to technical limitations and cost barriers. E-fuels are therefore most suitable for shipping and aviation (**European Parliament, 2023**).

53 In the absence of an internationally agreed, science-based international classification system, other instruments capable of guaranteeing the SDG-alignment of investments made with MDB funding will need to be in place. In any case, LMICs receiving MDB funding conditional to SDG-alignment will need support to ensure that they have sufficient capacity to ensure the SDG-alignment of the investments. Making sure that capital can be effectively spent effectively to align with the SDGs is key to ensure that the increase in the volume of finance that the international financial system can deploy is actually spent for what it is meant for.

54 The report also covers electricity, hydrogen and steel, all relevant for the ZEV discussion, and includes similar maps for these sectors.

55 L-category vehicles are a classification of road transport vehicles, based on the Consolidated resolution on the construction of vehicles of the United Nations (see **UNECE, 2017** for the last revision) that include powered two/three-wheelers (motorbikes, mopeds etc), quadricycles and 'micro cars'.

56 Opting for this solution would effectively switch the tax base to distance travelled rather than energy use. Charges could also potentially be differentiated to incentivise PHEVs to drive in all-electric mode, helping handle some of the resource availability challenges coming with BEVs. In addition to GHG emissions, air pollution and congestion, shifting to distance-based charges can also help to address other negative environmental and social externalities of road transport, in particular noise and traffic accidents (**OECD, 2019c**).

57 These were the Asian Development Bank (ADB), the Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC), CALSTART, Centro Mario Molina, the Dutch Government, the European Bank for Reconstruction and Development (EBRD), the German Agency for International Cooperation or Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the International Council on Clean Transportation (ICCT), the International Energy Agency (IEA), the International Transport Forum (ITF), the Organisation for Economic Co-operation and Development's Development Centre (OECD's Development Centre), Sustainable Energy for All (SEforALL), Partnership on Sustainable, Low Carbon Transport (SLOCAT), Transport Decarbonisation Alliance (TDA), the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP), the United Nations Economic Commission for Europe (UNECE), the United Nations Environment Programme (UNEP) and its office in Latin America (UNEP LAC), the United States State Government, the World Bank, the World Resources Institute (WRI), and the Wuppertal Institut.

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